Civics Group	Reg Number

Candidate Name: _____

JC2 Preliminary Examinations
2016 Higher 2

H2 BIOLOGY 9648/01

Paper 1 Multiple Choice Questions **22 September 2016**
1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write in soft pencils.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

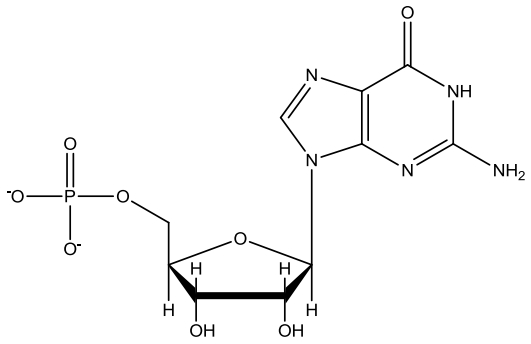
You may keep this booklet after the examination.

This paper consists of **22** printed pages.

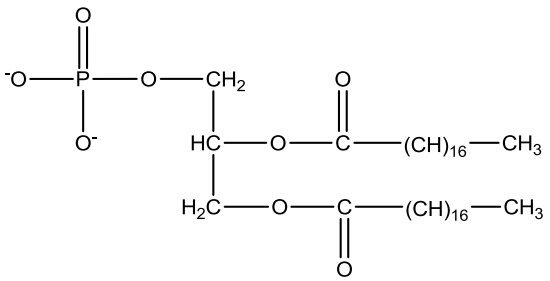
[Turn over]

QUESTION 1

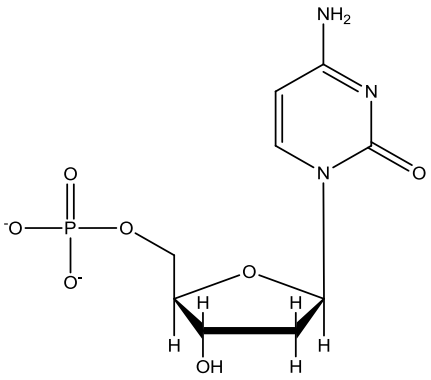
A student used centrifugation to separate the various intracellular structures of human liver cells by size and density. Which of the following molecule(s) would you expect to find in the fraction containing the mitochondria?



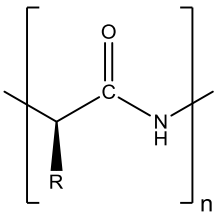
I



II



III



IV

A. II only

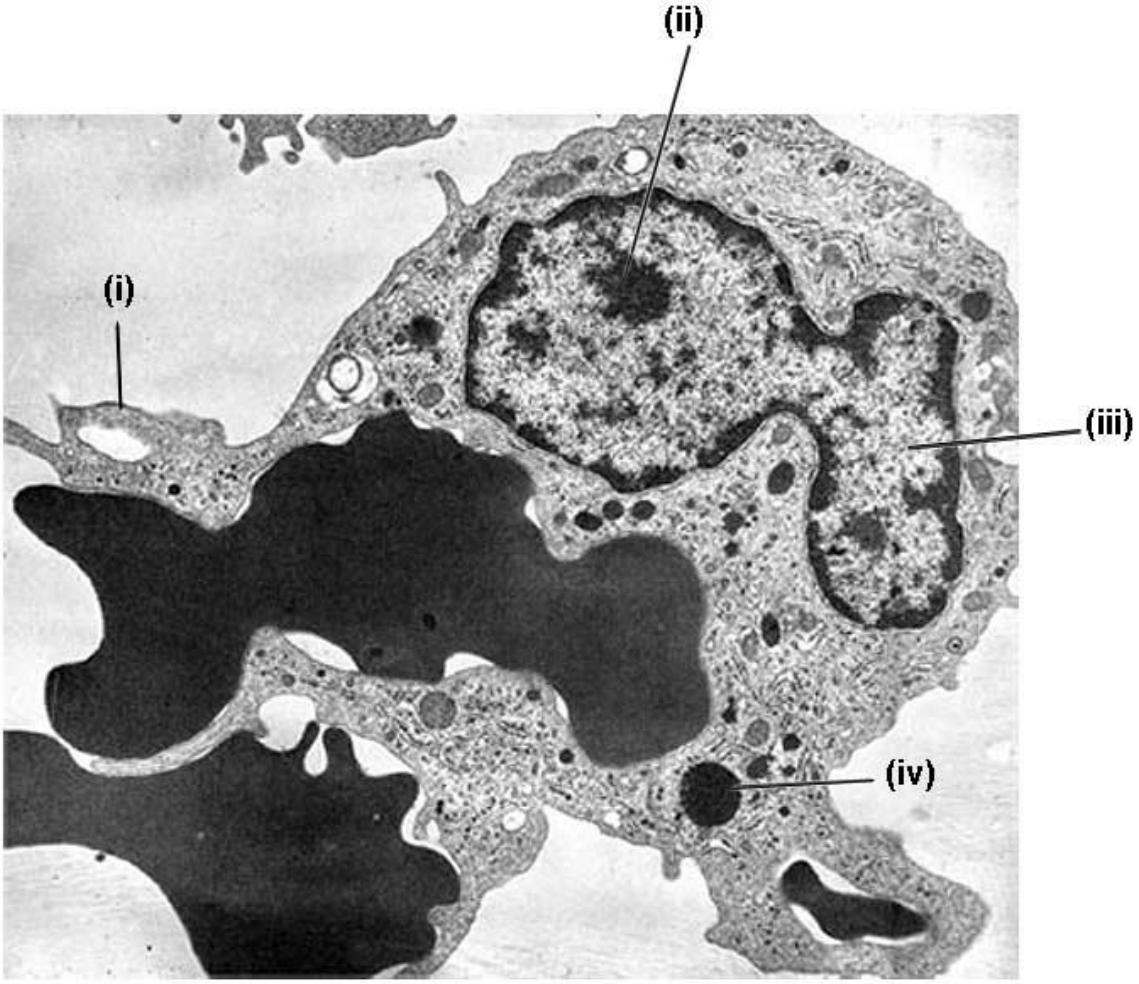
B. II and **IV** only

C. I, **II** and **IV** only

D. I, **II** , **III** and **IV**

QUESTION 2

The figure below is an electron micrograph of a human macrophage, a type of white blood cell.



Which of the options correctly matches structure with function?

	Structure (i)	Structure (ii)	Structure (iii)	Structure (iv)
A.	Engulfs foreign bacteria	Contains genes that code for hydrolytic enzymes	Transcription of ribosomal RNA	Contains enzymes for secretion
B.	Engulfs worn out red blood cells	Partial assembly of ribosomes	Contains genes that code for specific receptor proteins	Contains hydrolytic enzymes
C.	Engulfs foreign bacteria	Transcription of ribosomal RNA	Contains genes that code for specific receptor proteins	Contains enzymes for secretion
D.	Engulfs worn out red blood cells	Contains genes that code for hydrolytic enzymes	Transcription of ribosomal RNA	Contains hydrolytic enzymes

QUESTION 3

The phospholipid bilayer of a certain type of cell was analysed by separating the two layers and analysing the components of each layer.

Which option shows the composition of each layer?

A.	Glycolipids	Phospholipids	Glycoproteins	Cholesterol
Inner layer	0%	80%	0%	20%
Outer layer	15%	50%	15%	20%

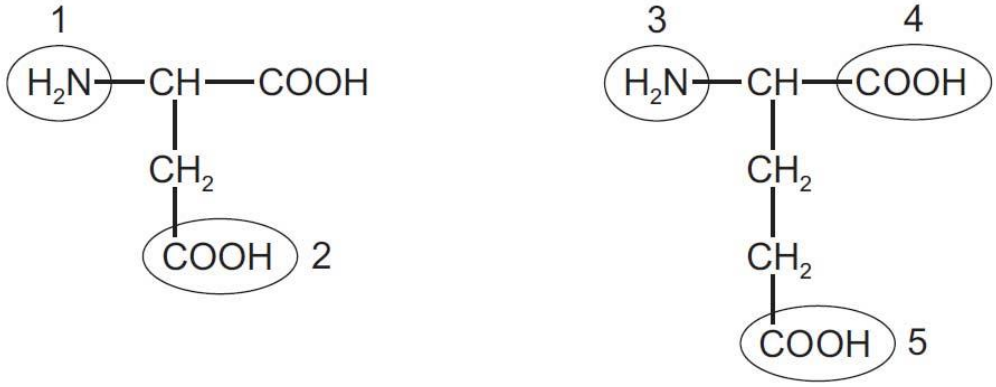
B.	Glycolipids	Phospholipids	Glycoproteins	Cholesterol
Inner layer	15%	50%	15%	20%
Outer layer	0%	80%	0%	20%

C.	Glycolipids	Phospholipids	Glycoproteins	Cholesterol
Inner layer	10%	60%	20%	10%
Outer layer	30%	50%	0%	20%

D.	Glycolipids	Phospholipids	Glycoproteins	Cholesterol
Inner layer	30%	50%	0%	20%
Outer layer	15%	50%	15%	20%

QUESTION 4

The diagrams show the structures of two amino acids, each of which has two carboxylic acid groups (–COOH).



Which groups form the bonds that maintain the configuration of α-helices?

A. 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

QUESTION 5

Which features adapt a cellulose molecule for its function?

1. Long chains of β-glucose molecules have multiple branches.
2. Many hydrogen bonds are formed between adjacent chains.
3. Cellulose is insoluble in water.

A. 1, 2 and 3 **B.** 1 and 3 only **C.** 2 and 3 only **D.** 2 only

QUESTION 6

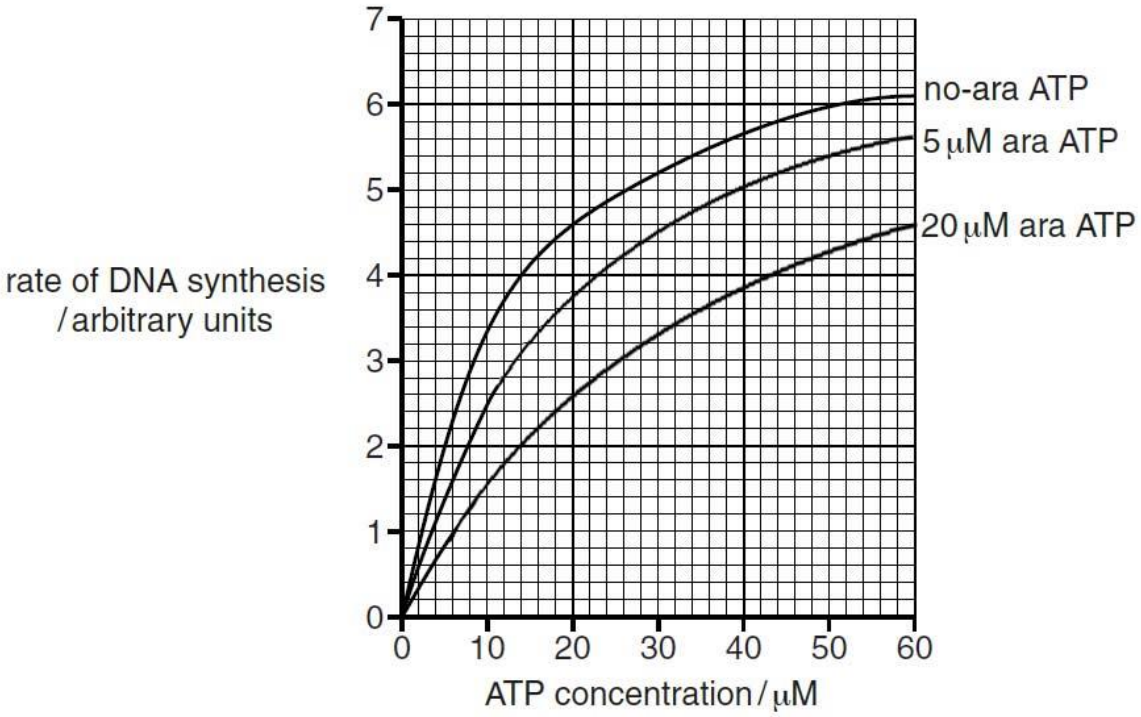
DNA polymerase is an enzyme involved in the replication of DNA. One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP

The results of the investigation are shown in the graph below:



Which of the following statements about the effects of ara-ATP are **false**?

1. ara-ATP binds to an allosteric site on DNA polymerase.
2. ara-ATP binds to the active site on DNA polymerase.
3. ara-ATP is similar in structure to ATP.
4. When ara-ATP binds to DNA polymerase, the shape of its active site changes.
5. When ara-ATP binds to DNA polymerase, the rate of DNA synthesis can be increased by increasing the concentration of ATP.

A. 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

QUESTION 7

Which is the correct statement concerning cell and nuclear division?

A. At prophase, the mass of DNA is doubled. Following anaphase, this mass is reduced by half and following cytokinesis this mass halves again.

B. Mutagens can cause mutations whereas carcinogens can cause cancer. This means that all mutagens are carcinogenic.

C. Some of the roles of mitosis are growth, asexual reproduction, cell repair following tissue damage and cell replacement.

D. Haploid eukaryotes can reproduce by mitosis whereas diploid eukaryotes can reproduce by mitosis or meiosis.

QUESTION 8

Some plants, such as wheat or banana plants, can produce diploid or haploid gametes. These gametes can fertilise other diploid or haploid gametes.

Which statements are correct for plants like these?

1. Diploid gametes may be produced by non-disjunction during meiosis.

2. The offspring will always show an increased chromosome number.

3. The offspring could be 2n, 3n or 4n.

4. The chromosome number could increase with each generation.

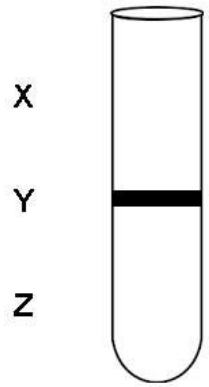
A. 1, 2 and 3 **B.** 1, 2 and 4 **C.** 1, 3 and 4 **D.** 2, 3 and 4

QUESTION 9

A culture of bacteria was allowed to reproduce using nucleotides containing ^{14}N for many generations. The culture was then allowed to reproduce using nucleotides with the heavy isotope of nitrogen, ^{15}N, for one generation. The DNA of the bacterial cells was then examined using a centrifuge before it was returned to a culture medium with nucleotides containing ^{14}N.

The DNA of the bacterial cells was then examined again after two subsequent generations in the culture medium with nucleotides containing ^{14}N.

The diagram below shows the position of the DNA band at **Y** in the centrifuge tube when the DNA was first labelled.

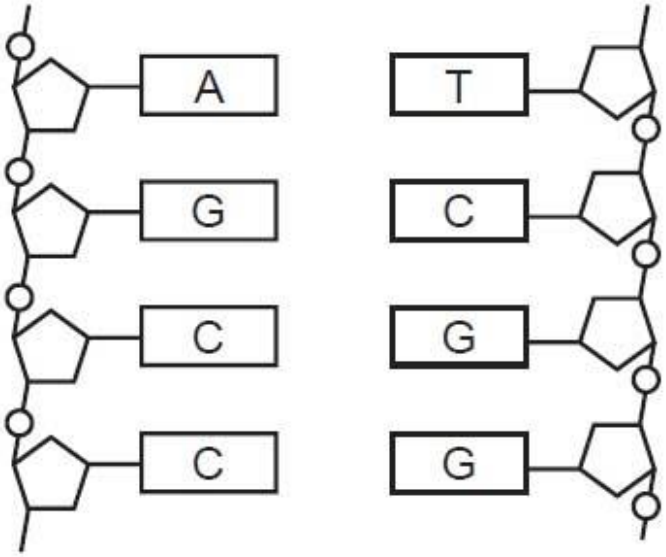


Which option shows the number of bands and their respective band positions for the two subsequent generations in the culture medium with nucleotides containing ^{14}N.

	After one generation in ^{14}N medium	**After another generation in ^{14}N medium**
A.	Two bands, 50% at **Y** and 50% at **Z**	Two bands, 75% at **Y** and 25% at **Z**
B.	Two bands, 50% at **Y** and 50% at **Z**	Two bands, 25% at **Y** and 75% at **Z**
C.	Two bands, 50% at **X** and 50% at **Y**	Two bands, 75% at **X** and 25% at **Y**
D.	Two bands, 50% at **X** and 50% at **Y**	Two bands, 25% at **X** and 75% at **Y**

QUESTION 10

The diagram shows part of a DNA molecule.



How many hydrogen bonds are involved in holding these strands of DNA together?

A. 12 **B.** 11 **C.** 9 **D.** 8

QUESTION 11

In 1985, it was discovered that a bacterium, *Mycoplasma capricolum*, used a deviant genetic code. The codon UGA resulted in the addition of tryptophan to the growing polypeptide chain.

A short sequence of nucleotides was synthesised with the following base sequence:

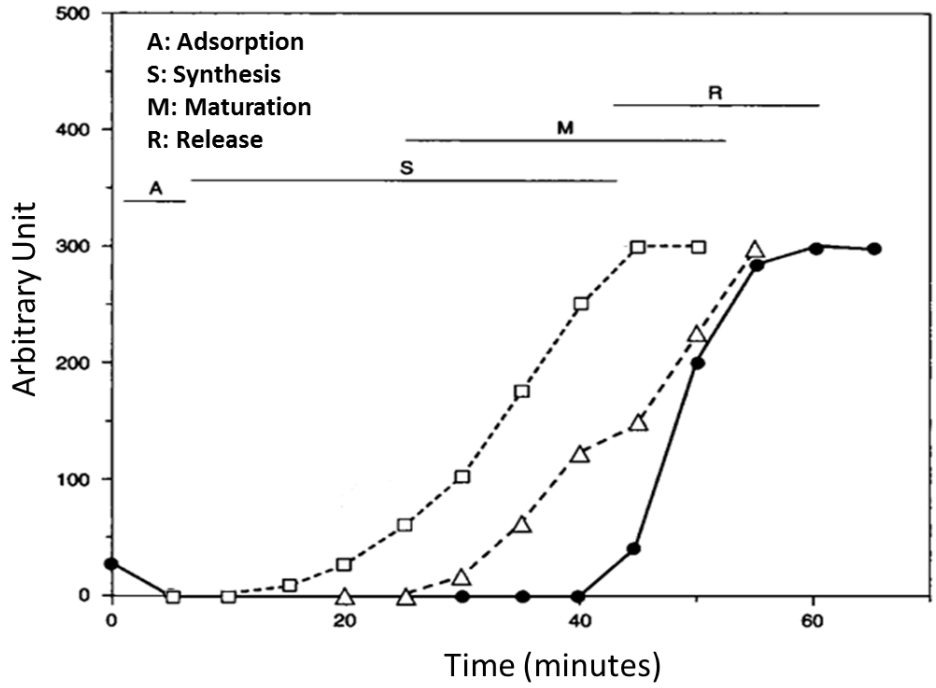
3' CTGGCAACTATTTCAACTCATATC 5'

How many peptide bonds would be formed by ribosomes when this sequence under goes transcription and translation in *Mycoplasma capricolum* and a human liver cell?

	Mycoplasma capricolum	Human liver cell
A.	1	0
B.	2	1
C.	3	2
D.	4	3

QUESTION 12

The graph represents the process of viral replication.



Which of the following option is correct?

	●	□	△
A.	extracellular virions	nucleic acids and proteins	intracellular viral particles
B.	extracellular virions	nucleic acids	intracellular viral particles
C.	intracellular viral particles	nucleic acids and proteins	extracellular virions
D.	intracellular viral particles	nucleic acids	extracellular virions

QUESTION 13

Which of the following correctly describe drugs that are effective in treating viral infection?

1. Antibiotics that induce the body to produce antibodies
2. Drugs that interfere with the synthesis of viral nucleic acid
3. Drugs that prevent viral protein synthesis by interfering with viral ribosomes
4. Drugs that change the cell surface receptor on the host cell
5. Drugs that prevent uncoating of the nucleocapsids

A. 2 and 5 **B.** 4 and 5 **C.** 2 and 3 **D.** 1 and 3

QUESTION 14
Which of the following statements is true for generalized and specialized transduction?

	Generalized	Specialized
A.	Transfers any bacterial DNA	Transfers one specific bacterial gene
B.	Contains a hybrid DNA in its capsid	Contains only bacterial DNA in its capsid
C.	The host cell will die	The host cell will not die
D.	Viral DNA is replicated by host cell machinery	Viral DNA is replicated by binary fission

QUESTION 15
Which statements about bacterial genetic transfer are **not** correct?

1. In transformation, bacterial cells which possess competence factors can only take up the plasmids from the surroundings.

2. Homologous recombination is always involved in bacterial genetic transfer.

3. After conjugation, the donor and recipient cells contain the same genetic information.

4. Binary fission will not contribute to genetic variation in bacterial cells without plasmids.

A. 1 and 3 **B.** 1, 2 and 3 **C.** 2 and 3 **D.** 1, 2, and 4

QUESTION 16
Which statement describes the difference between an inducible and repressible operon?

	Inducible operon	Repressible operon
A.	Functions in catabolic pathways	Functions in anabolic pathways
B.	Repressor genes are usually not expressed	Repressor genes are usually expressed
C.	Synthesizes inactive repressor	Synthesizes active repressor
D.	Repressor protein activated by substrate	Repressor protein repressed by substrate

QUESTION 17

In 1979, six groups of investigators independently reported the discovery of a p53 protein (encoded by *TP53* gene) that was present in human and mouse cells. One of the groups discovered that the p53 protein level was highly expressed in several types of mouse tumour cells. In 1980s, another research group discovered the association of high p53 protein level with human intestinal tumour cells but not normal cells.

What conclusion did the scientists arrive at based on the information above?

A. *TP53* is a tumour suppressor gene

B. *TP53* is a proto-oncogene

C. p53 is a transcription factor

D. *TP53* is not expressed in normal cells

QUESTION 18

Which statement concerning polypeptide synthesis is correct?

A. A particular cell type will transcribe all the genes present in one set of chromosomes but will only process particular pre-mRNA transcripts to enable polypeptide synthesis.

B. Different cell types contain different sets of genes to produce different pre-mRNA transcripts and synthesise different polypeptides.

C. The same pre-mRNA transcripts are synthesised by all cell types but different introns are removed from the transcripts before translation to synthesise polypeptides.

D. Different polypeptides can be synthesized from the same pre-mRNA in different cell types.

QUESTION 19

Gene expression in eukaryotes can be regulated at the translational level.

Which combination of statements correctly describes eukaryotic translational control?

	Condition	**Effect**
A.	Lack of translation initiation factor proteins	Inhibition of translation of selected mRNA
B.	Presence of repressor proteins binding to 5'-UTR of selected mRNA	Prevents small ribosomal subunit from binding
C.	Presence of repressor proteins to distal control elements	mRNA is translationally-repressed
D.	mRNA with a long poly-A tail	mRNA is degraded slowly by restriction endonuclease

QUESTION 20

In fruit flies, one gene controls wing form (normal or vestigial) and one gene controls eye colour (red or normal brown).

A fly with normal wings and normal brown eyes is crossed with a fly with vestigial wings and red eyes. All the F_1 are normal for both characteristics.

However, when F_1 are crossed with each other, the resulting F_2 is:

45 normal wing, normal brown eye
17 normal wing, red eye
16 vestigial wing, normal brown eye
5 vestigial wing, red eye
1 normal wing, orange eye

What is the best explanation for the results of this dihybrid cross?

A. Codominance

B. Gene mutation

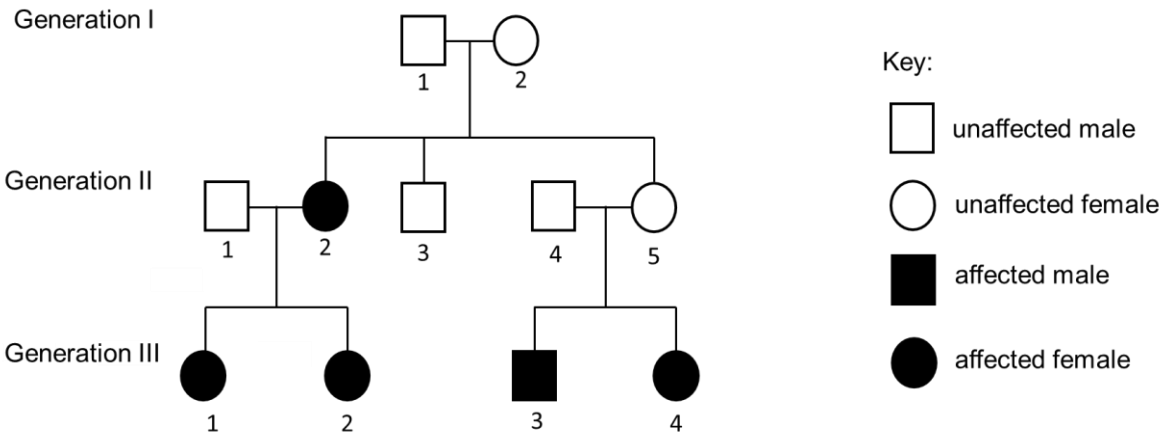
C. Multiple alleles

D. Sex linkage

QUESTION 21

Multiple Sclerosis (MS) is a neurodegenerative disease in which the immune system attacks the myelin that protects nerve fiber, upsetting the flow of information between the brain and the body.

The pedigree chart below shows the pattern of MS inheritance in a family.



Which of the following states the inheritance pattern of MS?

A. Sex-linked dominant

B. Sex-linked recessive

C. Autosomal dominant

D. Autosomal recessive

QUESTION 22

Two parents have a son who has blood group **O** and haemophilia. One parent has blood group **O** and the other has blood group **B**. Neither parent has haemophilia.

What is the probability that the second child of these parents is a son with blood group **B** who does not have haemophilia?

A. 1 in 4 **B.** 1 in 8 **C.** 2 in 4 **D.** 3 in 8

QUESTION 23

Feathers in poultry can be white or coloured and this is controlled by two genes, **P/p** and **Q/q**. The phenotypes of offspring that are expected from mating two birds, each of which is heterozygous at both loci, are shown in the Punnett square.

gametes	**PQ**	**Pq**	**pQ**	**pq**
PQ	white feathers	white feathers	white feathers	white feathers
Pq	white feathers	white feathers	white feathers	white feathers
pQ	white feathers	white feathers	coloured feathers	coloured feathers
pq	white feathers	white feathers	coloured feathers	white feathers

Which of the following best explains the proportion of white to coloured feathers in the Punnett square?

A. Dominant epistasis in which a suppressor prevents the expression of epistatic gene.

B. Dominant epistasis in which the epistatic allele is **P**.

C. Recessive epistasis in which colour is recessive to no colour at one allelic pair.

D. Recessive epistasis in which the epistatic allele is **p**.

QUESTION 24

Coat colour in rabbits is controlled by a gene with four alleles. The order of dominance for these alleles is as follows:

agouti (**C**) > chinchilla ($\mathbf{C^c}$) > himalayan ($\mathbf{C^h}$) > albino (**c**)

What is the maximum number of different coat colours obtained from a cross between an agouti rabbit and a Himalayan rabbit?

A. 1 **B.** 2 **C.** 3 **D.** 4

QUESTION 25

Which of the following statements is true?

A. Continuous variation shows a normal distribution and is only influenced by genetic factors.

B. Continuous variation is controlled by many genes and the traits are usually well defined with no gradation.

C. Discontinuous variation shows traits that follow discrete distribution and is mostly influenced by environmental factors.

D. Discontinuous variation shows traits that are controlled by one or two genes and is relatively unaffected by environmental factors.

QUESTION 26

Scorpions have a pair of grasping claws at the front of their bodies and a tail with a stinger. The stinger is used to inject venom into their prey to cause paralysis and convulsion.

Scorpion venom contains two active components:

- a toxin that affects ion channels at synapse of the nervous system of their prey
- an inhibitor of an enzyme found at these synapses

Which of the following statements **incorrectly** explain how the scorpion venom may stop the functioning of the synapse?

1. The toxin prevents the opening of the voltage-gated Na^+ channel at the presynaptic membrane while the inhibitor will cause the opening of the ligand-gated Na^+ channel.

2. Toxin will stop the release of the neurotransmitter into synaptic cleft and inhibitor will stop the recycling of neurotransmitter.

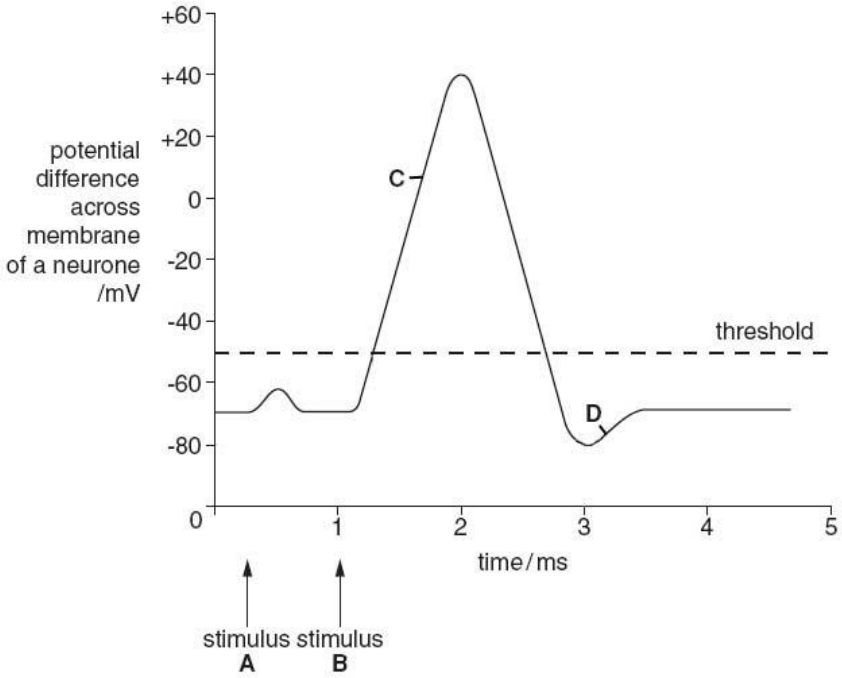
3. Toxin will prevent the entry of Na^+ ions into the postsynaptic knob and inhibitor will allow continuous depolarisation of postsynaptic membrane.

4. Both the toxin and inhibitor do not result in depolarisation of postsynaptic membrane.

A. 1 and 2 **B.** 2 and 3 **C.** 1 and 4 **D.** 3 and 4

QUESTION 27

The diagram shows an action potential.



1. Stimulus **B** is a stronger stimulus than stimulus **A** and will open more voltage-gated Na^+ channels to overcome the threshold potential.
2. At point **C**, the axon membrane is most permeable to sodium ions.
3. At point **D**, sodium conductance changes more slowly than potassium conductance.
4. A strong intensity stimulus can initiate a second action potential at point **D**.

How many of the above statement(s) is/are correct?

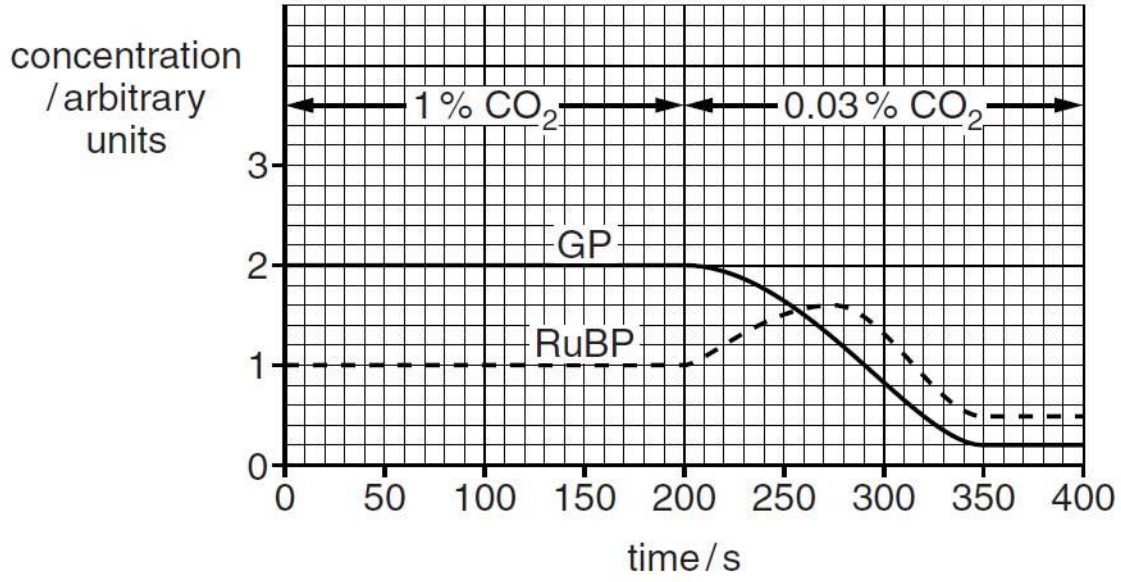
A. 1 **B.** 2 **C.** 3 **D.** 4

QUESTION 28

In an experiment, carbon dioxide concentration was altered to investigate its effects on the light-independent stage of photosynthesis.

- A cell suspension of *Chlorella* was illuminated using a bench lamp.
- The suspension was supplied with carbon dioxide at a concentration at 1% for 200 seconds.
- The concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- The concentrations of RuBP (ribulose bisphosphate) and GP (glycerate-3-phosphate) were measured at regular intervals.
- Throughout the investigation the temperature of the suspension was maintained at 25°C.

The results are shown below.



Which of the following statements is/are correct?

1. At 0.03% of CO_2, concentration of GP decreases due to the decrease in the rate of carbon fixation.

2. The concentration of RuBP increases between 210s and 250s due to more CO_2 fixation and more RuBP regenerated from triose phosphate.

3. There is an accumulation of triose phosphate between 250s to 290s.

4. There is an accumulation of RuBP in the chloroplast between 210s and 250s.

A. 1 and 4 **B.** 1 only **C.** 2 only **D.** 3 and 4

QUESTION 29

Both glucose and appropriate enzymes are necessary for the process of glycolysis to begin.

Which additional compound must also be present?

A. acetyl coenzyme A

B. ATP

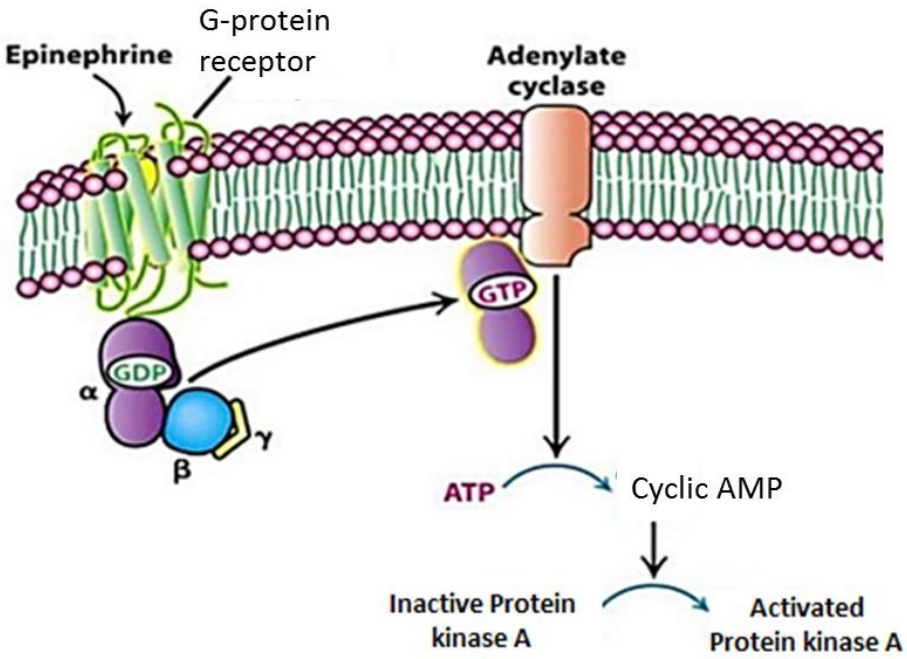
C. pyruvate

D. reduced NAD

QUESTION 30

The G protein-coupled receptor is activated by the binding of epinephrine to the receptor.

A mutation leads to constitutive signal transduction.



Which of the following explanations of the mutation are **incorrect**?

1. adenylate cyclase cannot bind to activated GTP
2. conformation change in G-protein receptor causes epinephrine to bind tightly
3. GTPase in G protein cannot hydrolyse GTP to GDP
4. conformation change in adenylate cyclase prevents the conversion of ATP to cyclic AMP

A. 1 and 3 **B.** 3 and 4 **C.** 1 and 4 **D.** 2 and 3

Question 31

Lucilia cuprina, the sheep blowfly, lays its eggs in wounds and the wet fleece of sheep. The larvae hatch and burrow into the sheep's skin, reduced wool production and sometimes cause death. Particular chemicals were used in the past to control the *L. cuprina* but these became less effective as sheep blowfly developed a resistance to the chemicals.

The cause of the increased resistance to the chemicals was most likely due to

A. farmers successively reducing the levels of insecticide applied to sheep.

B. the insecticide producing a change in a gene which enhanced the survival of the blowfly.

C. a chance mutation in a blowfly gene conferring a survival advantage in the chemical environment.

D. the insecticide producing a change in phenotype which enhanced reproduction of the blowfly.

Question 32

Which of the following options is correct?

	Factors that are important for a species to evolve by natural selection	**Evidence for evolution**
A.	Environmental change and inbreeding	Homologous structures and selective breeding of domesticated animals
B.	Environmental change and variation	Homologous structures and overproduction of offspring
C.	Variation and inbreeding	Homologous structures and overproduction of offspring
D.	Environmental change and variation	Homologous structures and selective breeding of domesticated animals

QUESTION 33

The following statements relate to molecular phylogenetics.

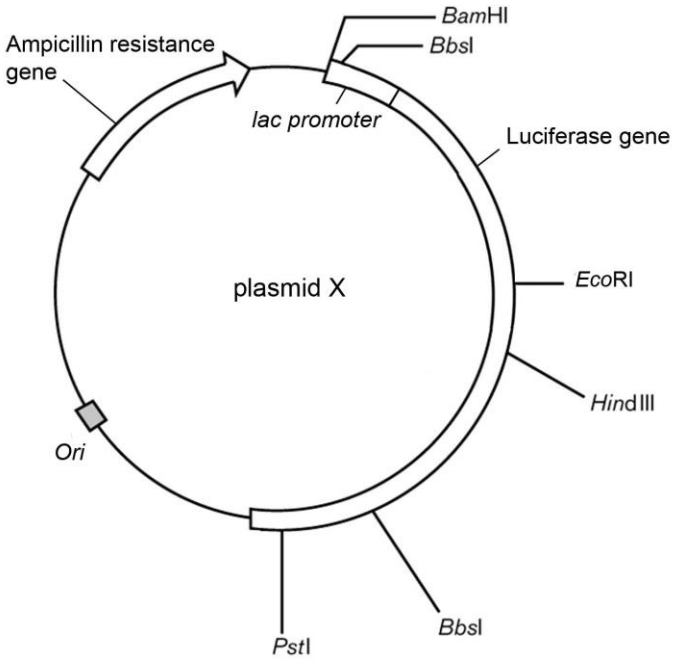
1. Lines of descent from a common ancestor to present-day organisms have undergone fixed rates of accumulation of DNA mutation in any given gene.
2. Organisms with similar base sequences in their DNA are closely related to each other.
3. The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.
4. Fossil records provide evidence for established periods of evolutionary divergence.

Which statements, when taken together, suggest the existence of a 'molecular clock' that enables scientists to estimate the time at which one species might have diverged from another?

A. 1 and 2 only **B.** 1 and 4 only **C.** 2 and 3 only **D.** 3 and 4 only

QUESTION 34

Plasmid **X** can serve as a vector for the insertion of genes to be cloned. Luciferase will allow the bacteria to emit light in presence of luciferin as a substrate.



How many possible restriction sites can be used for the expression of human growth hormone gene?

A. 1 **B.** 2 **C.** 3 **D.** 5

QUESTION 35

Synthesis of human insulin by genetically-modified bacteria involves the use of the enzyme reverse transcriptase.

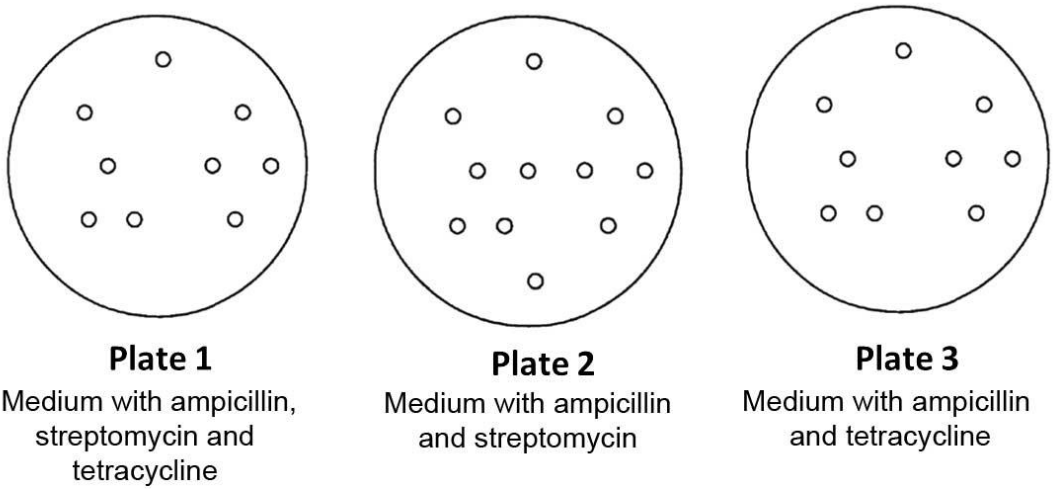
Which of the following statement(s) correctly describe(s) reverse transcriptase used in the above process?

1. It causes complementary DNA to be formed from mRNA
2. It causes single-stranded DNA to be converted to double-stranded DNA
3. It is found in prokaryotic cells
4. It is found in eukaryotic cells

A. 1 only **B.** 1 and 3 **C.** 2 and 4 **D.** 1 and 4

QUESTION 36

A gene coding for the production of a human gene product was inserted into a plasmid with genes coding for resistance to antibiotics ampicillin, streptomycin and tetracycline. The plasmids were used to transform *E. coli* and the bacteria were grown on a nutrient medium with various antibiotics using replica plating. The resulting plates are shown in the diagram.



Which antibiotic gene(s) contain(s) the restriction site that was used for the insertion of the human gene?

A. Ampicillin

B. Streptomycin

C. Tetracycline

D. Ampicillin and tetracycline

QUESTION 37
Which of the following statements about PCR are **false**?

1. The PCR cycle involves denaturation of the template, annealing of the RNA primers and polymerization of nucleotides.
2. PCR uses thermostable DNA-dependent DNA polymerases.
3. Magnesium ion ensures the stability of the thermostable DNA polymerases in PCR as it functions as a cofactor for the thermostable DNA polymerases in PCR.
4. Shorter duration of denaturation temperature at 95^{o}C is required if the DNA template has high guanine and cytosine content.

A. 1 and 3 **B.** 1 and 4 **C.** 2 and 3 **D.** 3 and 4

QUESTION 38
Which of the following is true of a genomic library?

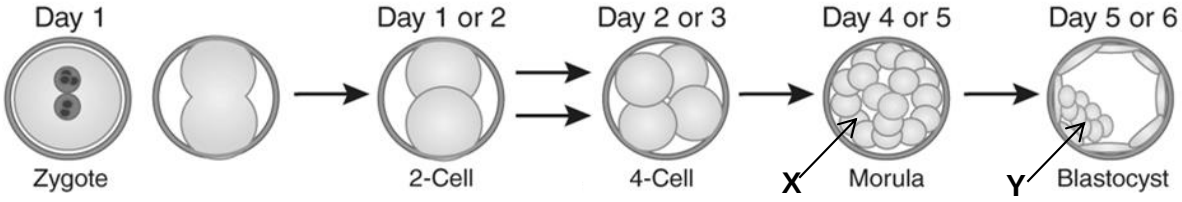
A. It is a collection of the different RFLPs of organisms within a population.

B. It is a collection of DNA fragments that make up the entire genome of a particular organism.

C. It is a collection of DNA fragments created by reverse transcriptase which are then inserted into vectors.

D. It is a collection of all genes of an organism's genome which have been sequenced.

QUESTION 39
The figure below shows several stages in the development of an embryo.



Which of the following statements is true about the cells labelled **X** and **Y**?

A. **X** is a pluripotent cell while **Y** is a multipotent cell.
B. **X** is a pluripotent cell while **Y** can give rise to multipotent cells.
C. **Y** will develop into the entire foetus including its placenta.
D. **X** can only give rise to totipotent cells but **Y** will give rise to pluripotent cells.

QUESTION 40

What are the possible arguments against the use of genetically modified organisms (GMOs)?

1. Insufficient testing of genetically modified crop for their side effects

2. Unforeseen long-term effects of genetic manipulation

3. Accidental genetic recombination in bacteria present in the lower intestines of humans as a result of consuming food derived from GMOs

4. Control of food supply by a small number of companies that have access to genetic engineering technology

A. 1 and 2 **B.** 2 and 3 **C.** 1, 2 and 3 **D.** 1, 2, 3 and 4

END OF PAPER 1

MERIDIAN JUNIOR COLLEGE
Preliminary Exam 2016
JC2 H2 (9648) BIOLOGY

ANSWERS

Multiple-Choice Question (40 marks)

Question	Answer	Question	Answer
1	**D**	21	**D**
2	**B**	22	**B**
3	**A**	23	**B**
4	**A**	24	**C**
5	**C**	25	**D**
6	**A**	26	**C**
7	**D**	27	**C**
8	**C**	28	**A**
9	**C**	29	**B**
10	**B**	30	**C**
11	**B**	31	**C**
12	**A**	32	**D**
13	**A**	33	**B**
14	**D**	34	**C**
15	**B**	35	**A**
16	**A**	36	**C**
17	**B**	37	**B**
18	**D**	38	**B**
19	**B**	39	**B**
20	**B**	40	**D**

JC2 Preliminary Examinations
2016 Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 5 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9648/02

Paper 2 Core Paper

16 September 2016
2 hours

Additional Materials: Answer papers

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions in the spaces provided on the question paper.

Section B
Answer **one** question on the answer paper provided.

At the end of the examination,
1. Fasten your answer papers to section B securely together.
2. Hand in the following separately:
   - Section A (Part I)
   - Section A (Part II)
   - Section B

The number of marks is given in brackets [ ] at the end of each question or part question.

For examiner's Use	
Section A	
1	/ 10
2	/ 9
3	/ 10
4	/11
5	/ 11
6	/ 9
7	/ 11
8	/ 9
Section B	
9 / 10	/ 20
Total	**/ 100**

This paper consists of **20** printed pages.

[Turn over]

Section A (Part I)

Answer **all** the questions in this section.

QUESTION 1

The structure of the tubulin dimer, the protein that forms microtubules by polymerisation, is shown in **Fig. 1.1**.

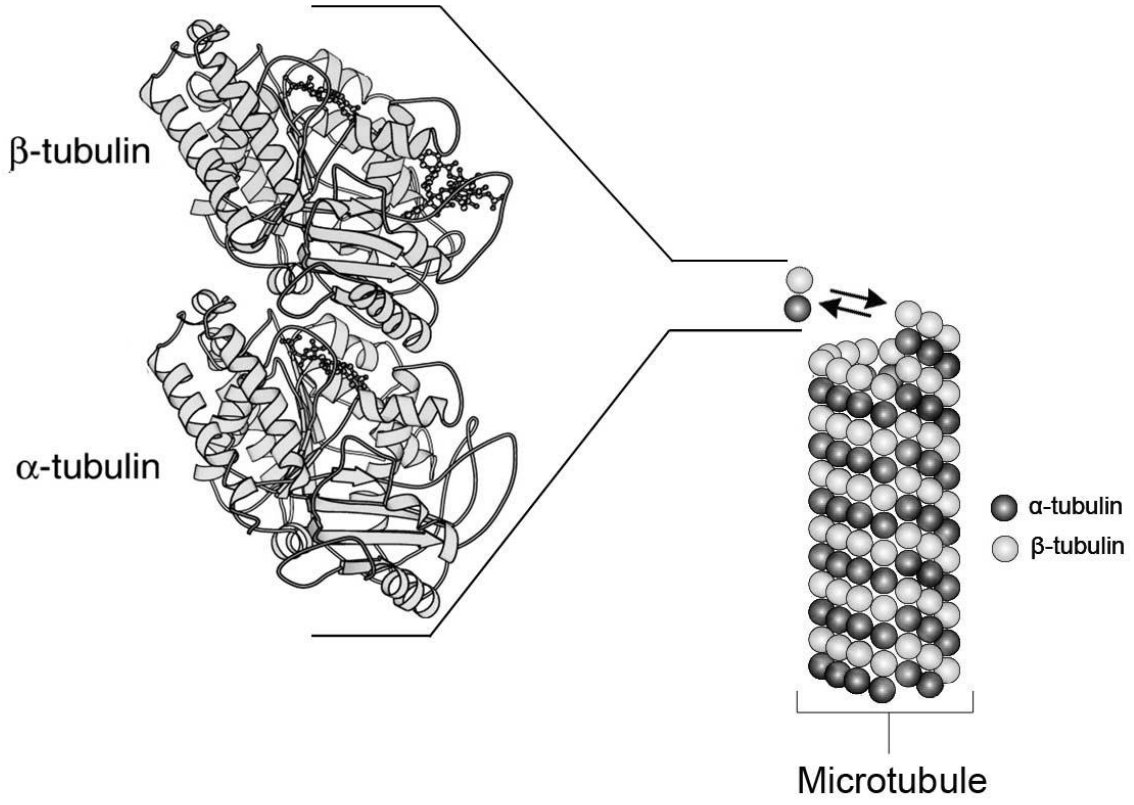


Fig. 1.1

(a) With reference to **Fig. 1.1**, name the secondary structures present in tubulin. [1]

……

……

Tubulin inhibitors like paclitaxel and vinblastine have been utilised in chemotherapy drug trials to treat cancers. All tubulin inhibitors are known to bind to the β-tubulin subunit.

(b) Explain how tubulin inhibitors reduce tumour formation. [3]

……

……

……

……

……

……

A trial was conducted to compare the effects of vinblastine and paclitaxel on the SKOV3 ovarian cancer cell line and the PC3 prostate cancer cell line.

For Examiner's Use

Table 1.1 below shows the results of the trial. The researcher measured the number of months in which the mass of tumours increased to critical mass after treatment with vinblastine and paclitaxel.

	No. of months in which the mass of tumours increased to critical mass	
	SKOV3	PC3
Untreated	0.5	1.0
Vinblastine	5.7	10.0
Paclitaxel	10.1	9.1

Table 1.1

(c) With reference to **Table 1.1**, compare the effects of vinblastine and paclitaxel on tumour growth in the two cancer cell lines. [4]

……..

……..

……..

……..

……..

……..

……..

……..

(d) Suggest and explain why different tumour cells may exhibit different levels of resistance to the same drug. [2]

……..

……..

……..

……..

[Total: 10]

QUESTION 2

Fig. 2.1 shows the process of translation.

For Examiner's Use

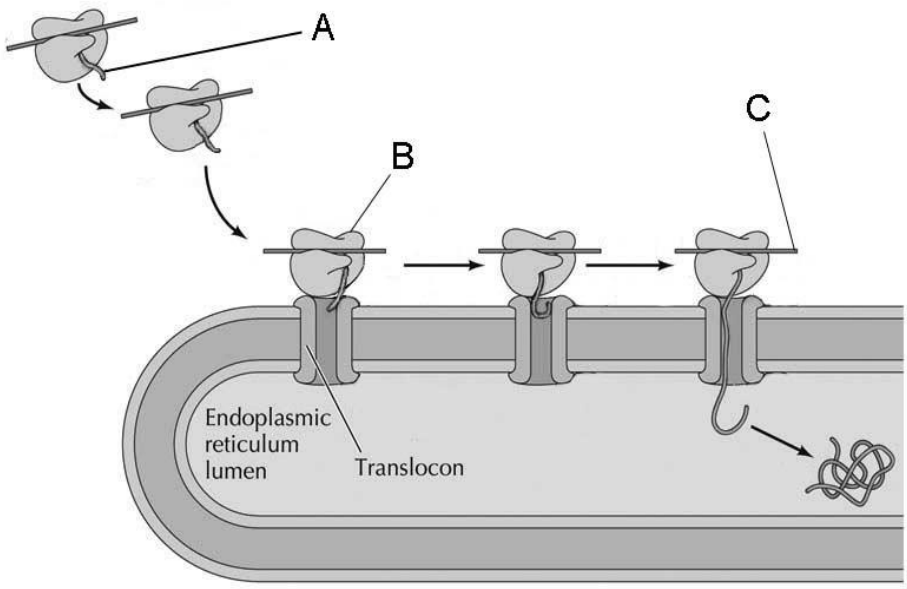


Fig. 2.1

(a) (i) Label structures **A**, **B** and **C**. [3]

A ……..

B……..

C ……..

(ii) Suggest the role of the translocon in protein synthesis. [1]

……..

……..

(b) List two ways in which transcription differs from DNA replication. [2]

1. ……..

……..

2. ……..

……..

(c) Explain how complementary base pairing facilitates the storage and transmission of genetic information. [3]

For Examiner's Use

……..

……..

……..

……..

……..

……..

[Total: 9]

.

QUESTION 3

For Examiner's Use

The measles virus (MV) is a spherical, non-segmented, single-stranded negative sense RNA virus. The structure of MV is shown in **Fig. 3.1.**

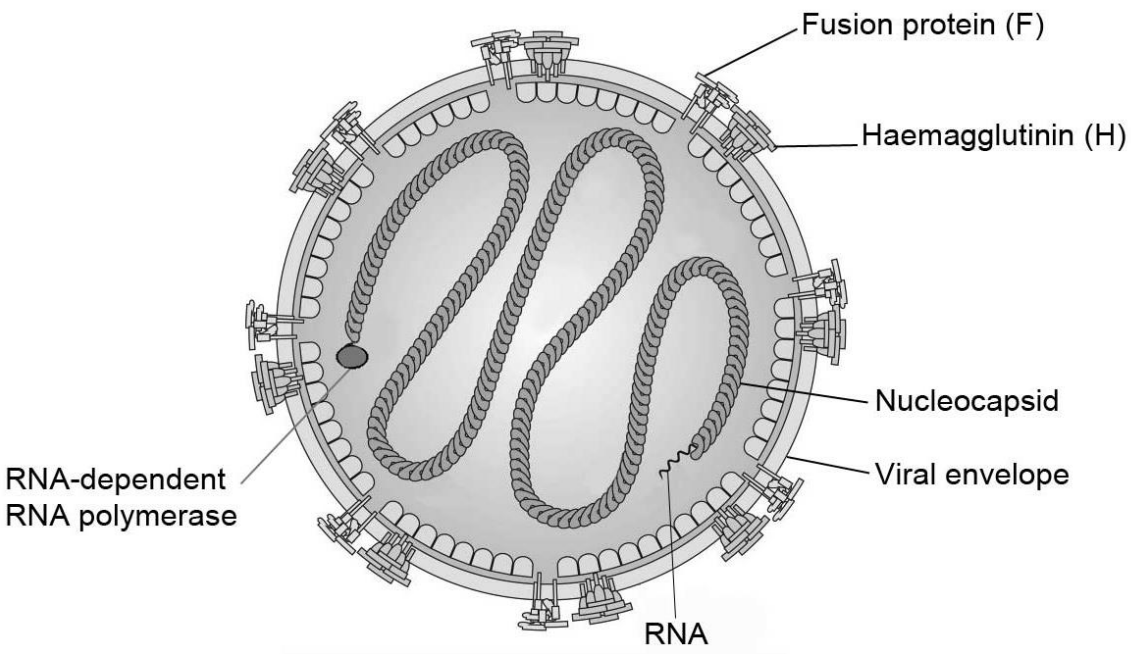


Fig. 3.1

(a) With reference to **Fig. 3.1**, describe two structural differences between MV and HIV. [2]

1. ……

……

2. ……

……

MV only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation molecule (SLAM). When MV infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

(b) With reference to **Fig. 3.1** and the information provided, suggest how MV infects a cell with SLAM glycoproteins. [3]

……

……

……

……

……

……

Both MV and HIV infect cells of the immune system. Upon infection, MV causes highly contagious measles which is an airborne disease spreads through the coughs and sneezes of those infected.

For Examiner's Use

(c) (i) Explain how HIV infection causes diseases. [4]

……..

……..

……..

……..

……..

……..

……..

……..

(ii) Suggest why MV is transmitted at a faster rate as compared to HIV. [1]

……..

……..

[Total: 10]

QUESTION 4

For Examiner's Use

(a) Telomerase is a ribonucleoprotein which comprises telomerase reverse transcriptase (TERT) protein and telomerase RNA.

Outline how telomerase is formed. [4]

……

……

……

……

……

……

……

……

During human embryonic development, telomerase activity is activated in embryonic stem cells to enable high proliferation rate of the cell. However, the telomerase activity is usually diminished after birth and the level of telomerase activity is absent in most of the somatic cells.

Fig. 4.1 shows the *TERT* promoter in the two types of cells.

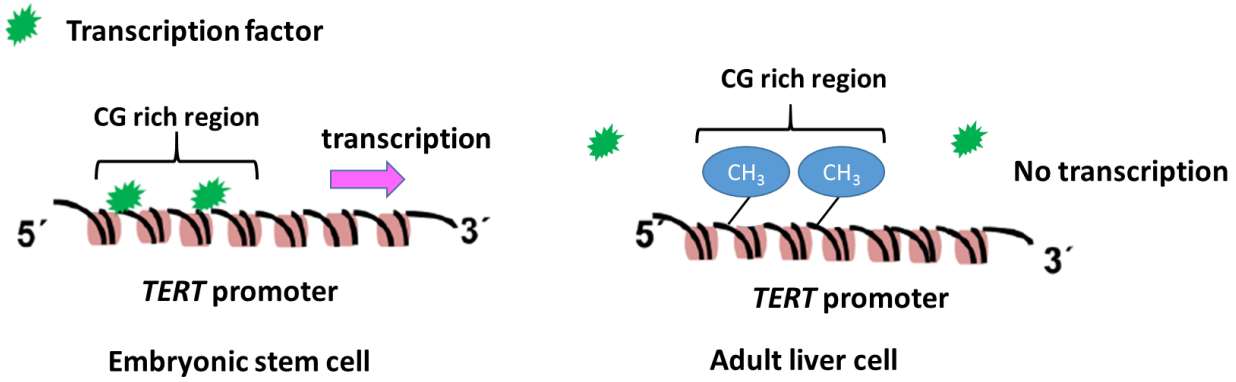


Fig. 4.1

(b) With reference to **Fig. 4.1** and your knowledge, explain why telomerase activity is absent in adult liver cells. [3]

……

……

……

……

……

……

(c) The process occurring in adult liver cells shown in **Fig. 4.1** also occurs in prokaryotic cells.

State how the outcome of the process in prokaryotes differs from that in adult liver cells. [1]

……

……

For Examiner's Use

(d) Outline the roles of telomeres in eukaryotic cells. [3]

……

……

……

……

……

……

[Total: 11]

QUESTION 5

For Examiner's Use

To study the inheritance of coat colour and eye colour in deer-mice, scientists performed two crosses and the table below shows the phenotypes of the F_1 generations from these two crosses.

Cross	Parents (pure bred)	F_1 phenotype	Number of F_1 progeny
1	Black eye, coloured female X Pink eye, albino male	All black eye, coloured mice	77
2	Black eye, coloured male X Pink eye, albino female	All black eye, coloured mice	68

The F_1 generation were then interbred and the following F_2 offspring were produced:

Black eye, coloured	295
Black eye, albino	42
Pink eye, coloured	46
Pink eye, albino	33

(a) Explain the purpose of carrying out crosses 1 and 2. [2]

……..

……..

……..

……..

(b) Using suitable symbols, draw a genetic diagram to explain the results of F_1 cross. [5]

For Examiner's Use

(c) State the expected ratio of the F_2 phenotypes if Mendelian law applies to the two gene loci. [1]

For Examiner's Use

……..

The chi-squared (χ^2) test was performed on these results, giving a calculated value for χ^2 of 47.527.

The χ^2 distribution table and equation to calculate χ^2 is shown below.

number of degrees of freedom (v)	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

(d) Using the calculated value of χ^2 and the table of probabilities provided in the table above, explain the conclusions drawn from the (χ^2) test. [3]

……..

……..

……..

……..

……..

……..

[Total: 11]

Candidate Name	Civics Group	Index No.

For Examiner's Use

Meridian Junior College
JC2 Preliminary Examinations 2016
H2 Biology (9648/02)

Question 6	Question 7	Question 8
/ 9	/ 11	/ 9

Section A (Part II)
Answer **all** the questions in this section.

QUESTION 6

Two groups of white mustard plants, *Sinapis alba*, were grown, one group under high illumination, the other under low illumination. When fully grown, the effect of increasing light intensity on the rate of photosynthesis in the two groups of plants was measured.

Fig. 6.1 shows the results.

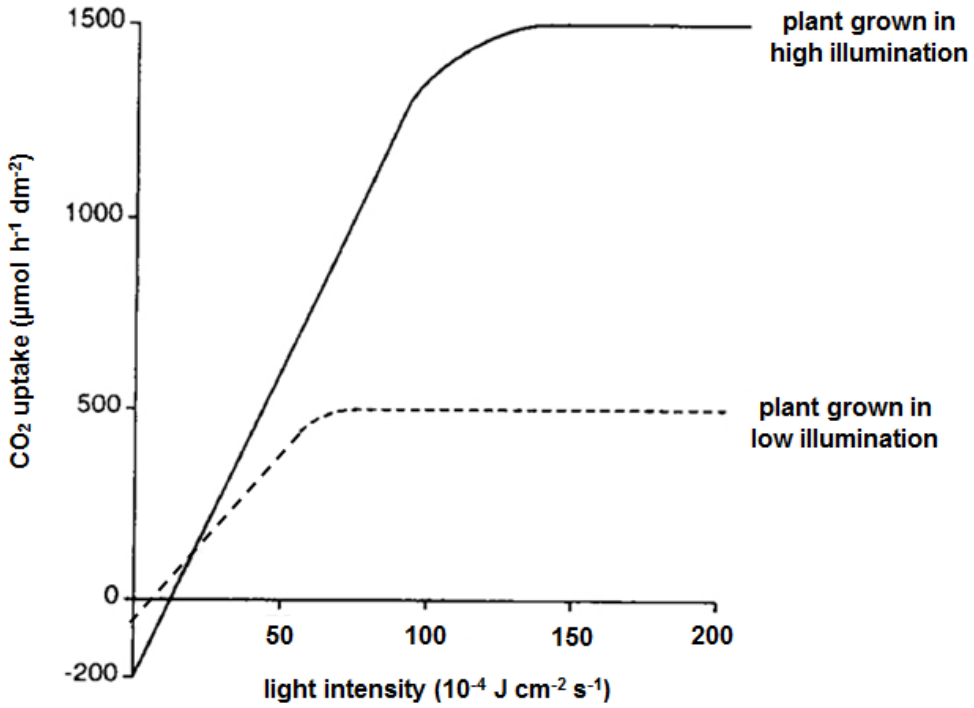


Fig. 6.1

(a) With reference to **Fig. 6.1**,

(i) state and explain the effect of light intensities above 150 x 10^{-4} $Jcm^{-2}s^{-1}$ on the rate of photosynthesis in plants grown in high illumination. [2]

……

……

……

……

(ii) state with evidence, **two** ways in which the carbon dioxide uptake of both plants differ at light intensities below 50 x 10^{-4} $Jcm^{-2}s^{-1}$. [4]

For Examiner's Use

……..

……..

……..

……..

……..

……..

……..

……..

(b) Outline the fate of each product of photolysis in the light dependent reaction. [3]

……..

……..

……..

……..

……..

……..

[Total: 9]

QUESTION 7

For Examiner's Use

Fig. 7.1 is an electron micrograph of a section through a myelinated neurone showing the Schwann cell and axon membrane.

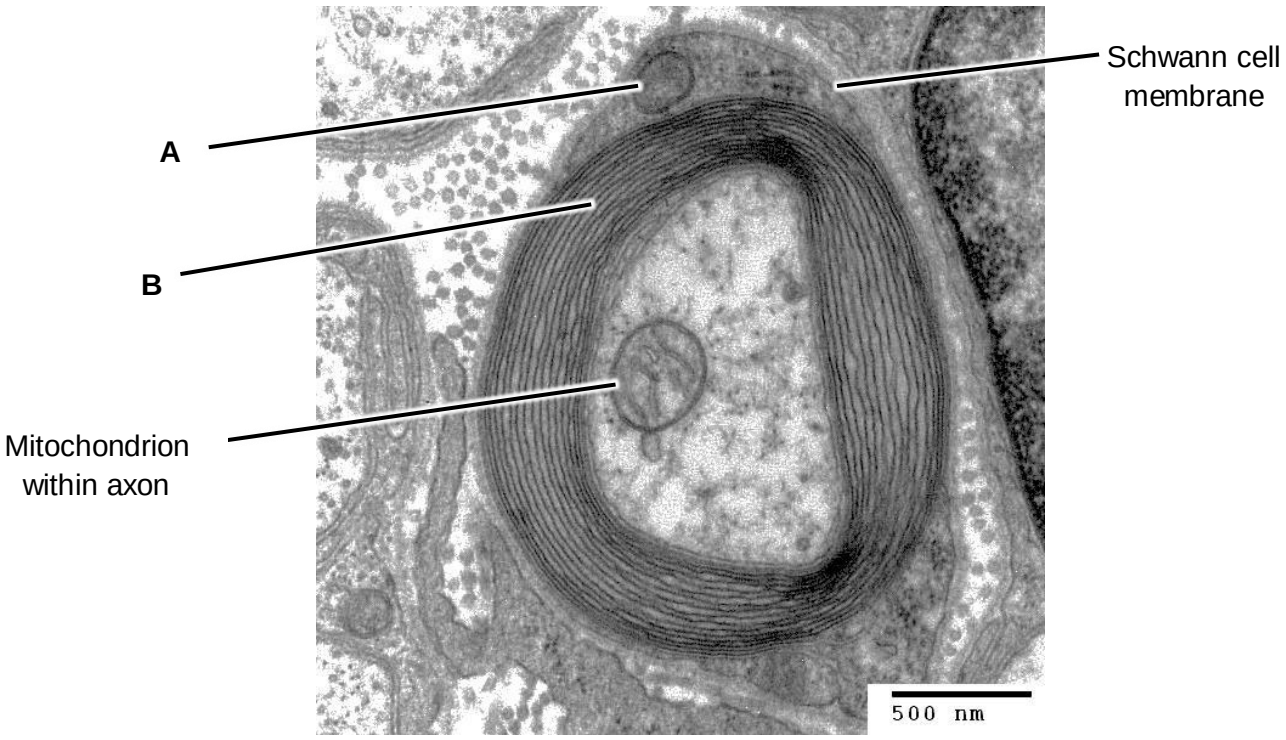


Fig. 7.1

(a) Identify the structures labelled **A** and **B**. [2]

A ……

B ……

(b) **Fig. 7.2** shows the percentage of energy used for various processes involved in the maintenance of resting potentials and in the reception and transmission of action potentials by a neuron.

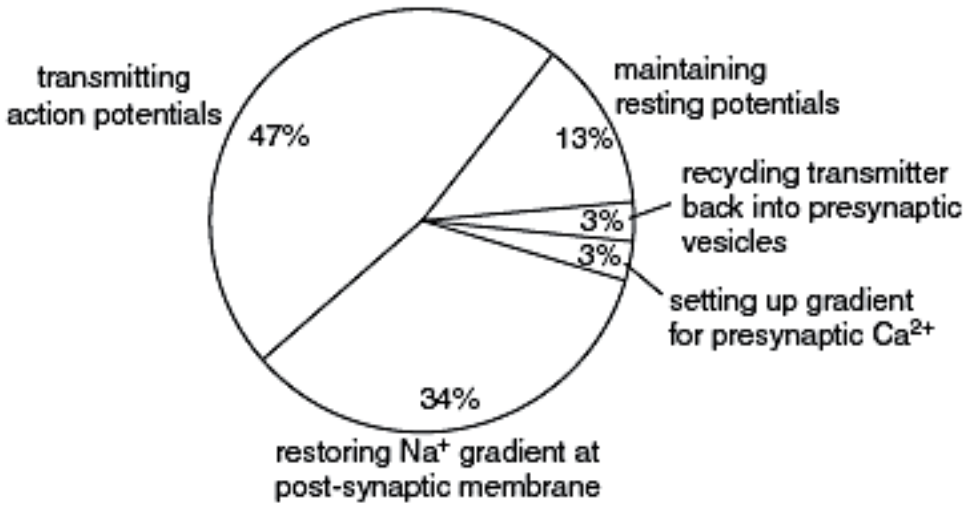


Fig. 7.2

(i) Explain why maintaining a resting potential requires energy. [2]

For Examiner's Use

……

……

……

……

(ii) Neurons contain large numbers of mitochondria. There are more mitochondria in each dendrite than in the axon.

With reference to **Fig. 7.2**, suggest reasons for the distribution of mitochondria. [3]

……

……

……

……

……

……

(c) Describe the role of Ca^{2+} in the passage of impulses across a synapse. [2]

……

……

……

……

(d) Synapses slow down the rate of transmission of nerve impulses but serve other important roles in the nervous system.

Outline two roles of synapses in the nervous system. [2]

1. ……

……

2. ……

……

[Total: 11]

QUESTION 8

For Examiner's Use

Mole rats, *Spalax ehrenbergi,* are mammals that live in groups in underground burrows. They are blind, and communicate with each other through sound and scent. Males make a purring call when they attempt to persuade females to mate with them.

In Israel, the mole rats found in different parts of the country all look identical. However, there are actually four different populations with different chromosome numbers, which live in different climatic regions.

Table 8.1 shows the four populations of mole rats and information about the purring calls used by the males in each population. The call of the males were analysed by measuring the number of sound pulses per second, and also the frequencies of the sounds that they made.

Chromosome number of population		52	54	58	60
Climatic region in which population lives		Cool and humid	Cool and dry	Warm and humid	Warm and dry
Purring call made by males	Mean number of pulses per second	21.0	25.3	23.9	23.2
	Mean major frequency/ kHz	595	555	583	562

Table 8.1

Researchers investigated how female mole rats from each of the four populations responded to purring calls made by males from the same population, and by males from different populations.

A female was placed midway between two loudspeakers, and recorded calls from two males were played to her simultaneously. The researchers noted which loudspeaker the female moved towards. This was repeated with many different females from each population.

The results are shown in **Table 8.2.**

Population chromosome number	Percentage of females preferring the purring call of males from their own population
52	79
54	77
58	78
60	44

Table 8.2

(a) With reference to **Table 8.2**, describe the extent to which female mole rats show a preference for the purring calls of males from their own population. [2]

For Examiner's Use

……

……

……

……

(b) With reference to the data in both **Table 8.1** and **Table 8.2**, discuss whether these four populations of mole rats should be classified as different species. [4]

……

……

……

……

……

……

……

……

The phylogenetic relationship of seven genera of mole rats was investigated using nucleotide sequences of the *12S rRNA* gene obtained from mitochondrial DNA.

Fig. 8.1 shows a phylogenetic tree of the mole rats based on this *rRNA* gene nucleotide sequence data.

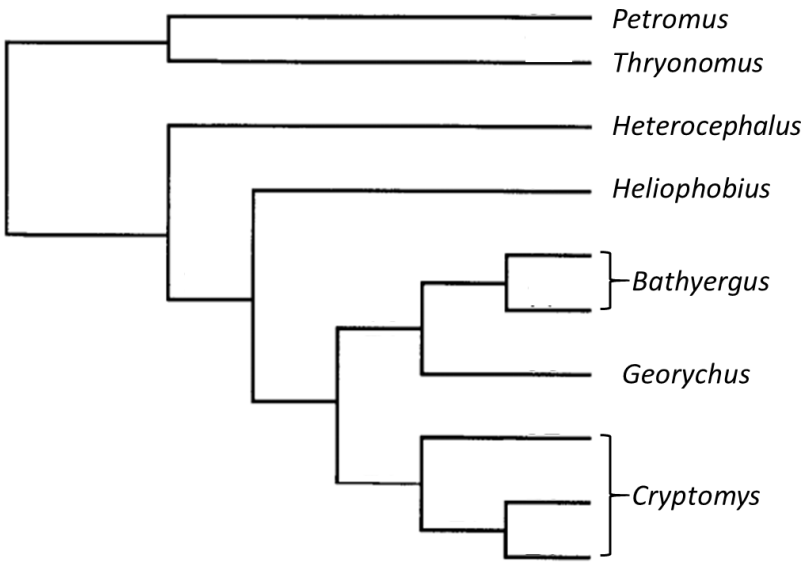


Fig. 8.1

(c) Describe the advantages of using nucleotide data such as the *12S rRNA* gene in classifying the mole rats. [3]

For Examiner's Use

……

……

……

……

……

……

[Total: 9]

Section B
Answer **one** question.

For Examiner's Use

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be in set out in questions **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 9

(a) Describe the role of vesicles in a cell. [6]

(b) Describe one causative factor of cancer and explain how this factor increases the chances of cancerous growth. [6]

(c) Describe the differences between the control of gene expression in prokaryotic and eukaryotic cells. [8]

[Total: 20]

QUESTION 10

(a) Describe the structure of collagen and how it is related to its function. [8]

(b) Explain why antibiotic resistance spreads so rapidly among bacteria. [6]

(c) Describe the main differences between glucagon and insulin signalling in liver cells. [6]

[Total: 20]

• END OF PAPER 2 •

JC2 Preliminary
Examinations 2016 Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 5 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9648/02

Paper 2 Core Paper

16 September 2016
2 hours

Additional Materials: Answer papers

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions in the spaces provided on the question paper.

Section B
Answer **one** question on the answer paper provided.

At the end of the examination,
1. Fasten your answer papers to section B securely together.
2. Hand in the following separately:
   - Section A (Part I)
   - Section A (Part II)
   - Section B

The number of marks is given in brackets [ ] at the end of each question or part question.

ANSWER SCHEME

For examiner's Use	
Section A	
1	/ 10
2	/ 9
3	/ 10
4	/11
5	/ 11
6	/ 9
7	/ 11
8	/ 9
Section B	
9 / 10	/ 20
Total	**/ 100**

This paper consists of __ printed pages.

[Turn over]

Section A (Part I)
Answer **all** the questions in this section.

QUESTION 1
The structure of the tubulin dimer, the protein that forms microtubules by polymerisation, is shown in **Fig. 1.1**.

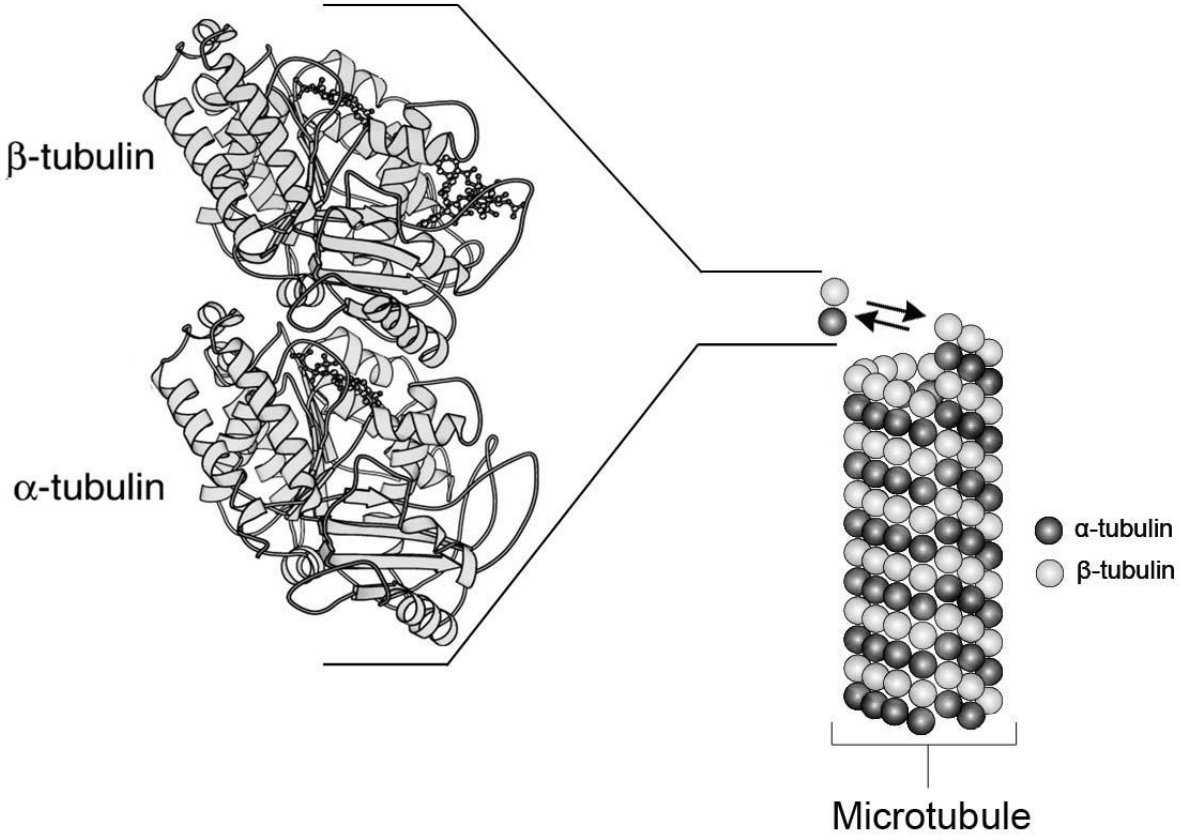


Fig. 1.1

(a) With reference to **Fig. 1.1**, name the secondary structures present in tubulin. [1]

- **α-helices and β-pleated sheets.**

Tubulin inhibitors like paclitaxel and vinblastine have been utilised in chemotherapy drug trials to treat cancers. All tubulin inhibitors are known to bind to the β-tubulin subunit.

(b) Explain how tubulin inhibitors reduce tumour formation. [3]

- Tubulin inhibitors **interfere / prevent polymerisation** of tubulin dimers to form microtubules / **spindle fibres** that make up the **mitotic spindle**.
- Without spindle fibres, **chromosomes cannot divide** / mitosis **stops at prophase** / mitosis **cannot take place**.
- Hence affected cells **exit the cell cycle / go into G_0** and **uncontrolled cell division is prevented**.

A trial was conducted to compare the effects of vinblastine and paclitaxel on the SKOV3 ovarian cancer cell line and the PC3 prostate cancer cell line.

Table 1.1 below shows the results of the trial. The researcher measured the number of months in which the mass of tumours increased to critical mass after treatment with vinblastine and paclitaxel.

	No. of months in which the mass of tumours increased to critical mass	
	SKOV3	PC3
Untreated	0.5	1.0
Vinblastine	5.7	10.0
Paclitaxel	10.1	9.1

Table 1.1

(c) With reference to **Table 1.1**, compare the effects of vinblastine and paclitaxel on tumour growth in the two cancer cell lines. [4]

Similarities (max 2):

- **Both** vinblastine and paclitaxel **reduces** / **slowed down tumour growth** in **both** the SKOV3 and PC3 cells lines. [Coupled with data citation]

- Vinblastine and paclitaxel were **equally effective** in slowing down tumour growth in **PC3** tumours.

    - Data citation: **Untreated SKOV3 tumours** grew critical mass in **0.5 months** as compared to tumour cells treated with **vinblastine** which only grew to critical mass after **5.7 months** and tumour cells treated with **paclitaxel** which only grew to critical mass after **10.1 months**.

    - Data citation: **Untreated PC3 tumours** grew to critical mass in **1.0 months** as compared to tumour cells treated with **vinblastine** which only grew to critical mass after **10.0 months** and tumour cells **treated** with **paclitaxel** which only grew to critical mass after **9.0 months**.

Differences (max 2):

- Vinblastine **slowed down tumour growth to a lesser extent / was less effective in treating the SKOV3 cell lines** as compared to paclitaxel. [Coupled with data citation]

    - SKOV3 tumour cells **treated** with **vinblastine** grew to critical mass in **5.7 months** as compared to SKOV3 cells treated with **paclitaxel** which only grew to critical mass after **10.1 months**.

(d) Suggest and explain why different tumour cells may exhibit different levels of resistance to the same drug. [2]

- Different tumour cells exhibit **variation due to random mutation** to certain genes / **differential gene expression** / **gene amplification**.
- Leading to formation of new alleles coding for / more functional proteins that serve as

    - **transporter proteins** that **pump out** drugs.
    - **Tubulin** with a non-complementary **binding site** where the drug usually binds to.
    - **enzymes** that **hydrolyses** the drug.
    - **inhibitors** that bind to the drugs and render them ineffective.
    - AVP, e.g. cell surface receptors, proteins that regulate the cell cycle, etc

[Total: 10]

QUESTION 2

Fig. 2.1 shows the process of translation.

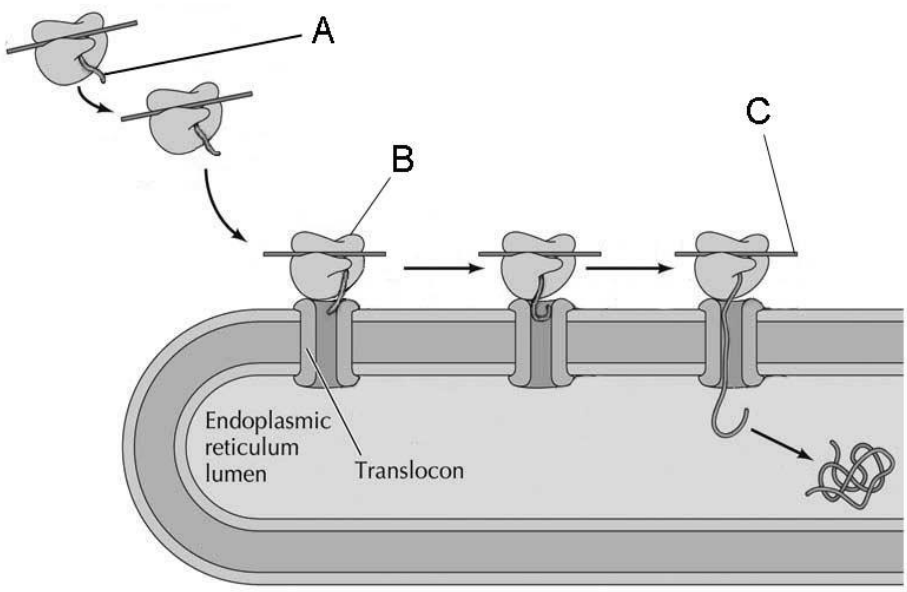


Fig. 2.1

(a) (i) Label structures **A**, **B** and **C**. [3]

- A – polypeptide chain
- B – small ribosomal subunit (accept ribosome)
- C – mRNA

(ii) Suggest the role of the translocon in protein synthesis. [1]

- The translocon serves as a **hydrophilic channel** to allow the passage of the polypeptide chain into the **lumen** of the endoplasmic reticulum.

(b) List two ways in which transcription differs from DNA replication. [2]

	DNA Replication	**Transcription**
Template	Both strands of DNA	Template strand / one of two DNA strands
Raw materials	Deoxyribonucleotides	riboxynucleotides
Final product	DNA	mRNA, rRNA, tRNA
Enzymes that catalyse the formation of the bonds between monomers	DNA Polymerase catalyses the formation of phosphodiester bonds between deoxyribonucleotides	RNA Polymerase catalyses the formation of phosphodiester bonds between ribonucleotides

(c) Explain how complementary base pairing facilitates the storage and transmission of genetic information. [3]

- [Compulsory for Storage] Complementary base pairing between bases of the two template strands / parental strands is important as it **stabilises** the **double-stranded helix structure** of DNA for storage of genetic information.

- [Transmission] Complementary base pairing enables . . .

- [Replication] the **formation of daughter strands during DNA replication** before mitosis in order to transmit genetic information to daughter cells.
- [Replication] the **proofreading function of DNA polymerase to find and repair mutations** to maintain genetic fidelity.

- [Transcription] the **formation of mRNA during transcription** in order to **transmit information** for the synthesis of **the primary sequence of polypeptides** in protein synthesis. [Mention of the type of genetic information – mark **once** in either this point or the next]

- [Translation] Complementary base pairing **between mRNA codons and tRNA anticodons during translation** transmits information for the primary sequence of polypeptides in protein synthesis.

[Total: 9]

QUESTION 3

The measles virus (MV) is a spherical, non-segmented, single-stranded negative sense RNA virus. The structure of MV is shown in **Fig. 3.1.**

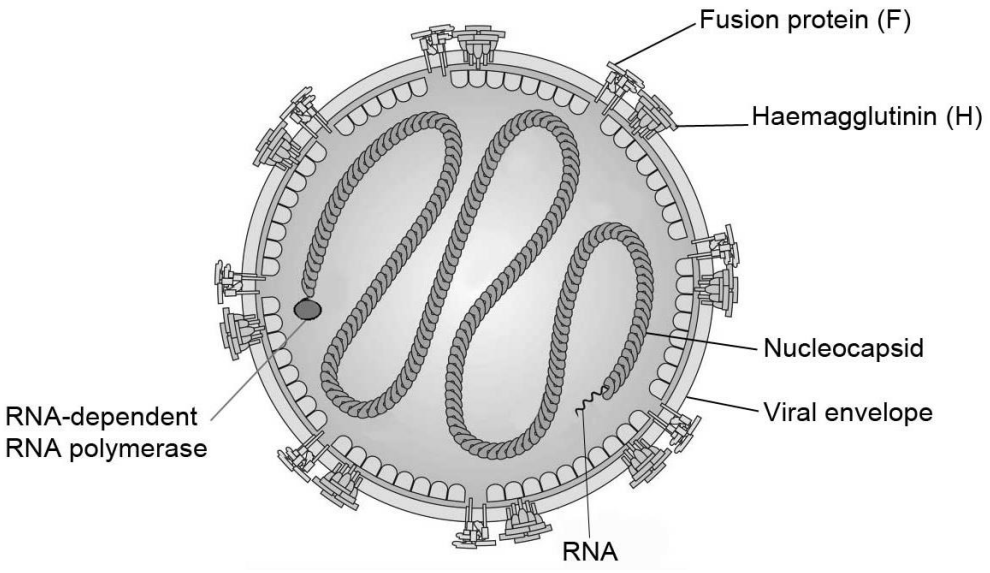


Fig. 3.1

(a) With reference to **Fig. 3.1**, describe two structural differences between MV and HIV. [2]

- **The glycoproteins** embedded in the envelope of MV consist of **Haemagglutinin/H and fusion protein/F** whereas in HIV they are **gp120 and gp41**.
- HIV contains a **capsid surrounding the nucleocapsid** whereas **MV does not.**
- HIV carries **two copies** of linear **(+) single-stranded RNA** for its genome whereas MV carries one copy of **(-) single-stranded RNA**
- HIV contains **reverse transcriptase** whereas MV contains **RNA-dependent RNA polymerase**.

MV only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation molecule (SLAM). When MV infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

(b) With reference to **Fig. 3.1** and the information provided, suggest how MV infects a cell with SLAM glycoproteins. [3]

- **Haemagglutinin/H** is **complementary in shape to** the **binding site of SLAM receptor**
- **Fusion protein /F** causes **fusion of the viral envelope** to the **cell surface membrane**
- which **releases nucleoprotein and viral polymerase** for viral replication

Both MV and HIV infect cells of the immune system. Upon infection, MV causes highly contagious measles which is an airborne disease spreads through the coughs and sneezes of those infected.

(c) **(i)** Explain how HIV infection causes diseases. [4]

- *Idea that* HIV infects and kills T helper cells [all descriptions about the death of T-cells fall under this point].
- *Idea that* **B lymphocytes cannot produce antibodies** without the help of T lymphocytes.
- This **compromise the immune system**. Leading to **opportunistic infections**
- **Integration of viral DNA** into **proto-oncogene** of the host genome, which may also cause **cancer.**

(ii) Suggest why MV is transmitted at a faster rate as compared to HIV. [1]

- The mode of transmission of MV is **through aerosol/droplet** (OWTTE) hence spread more easily whereas HIV is transmitted through **transfer of body fluids (**OWTTE**).**

[Total: 10]

QUESTION 4

(a) Telomerase is a ribonucleoprotein which comprises telomerase reverse transcriptase (TERT) protein and telomerase RNA.

Outline how telomerase is formed. [4]

- **Telomerase RNA** is produced through **transcription** of the **telomerase RNA genes** in the nucleus (must differentiate between Telomerase RNA gene and TERT gene!)
- Idea that the telomerase RNA folds into a 3D structure and remain in the nucleus
- **Genes of TERT** are transcribed in nucleus to form **TERT mRNA…**
- …which is **translated** by free **ribosomes** in cytosol to form **TERT proteins**
- **TERT protein** is **transported from the cytoplasm into nucleus** via nuclear pore
- **Assembly of telomerase RNA and TERT proteins** into telomerase in the **nucleus**.

During human embryonic development, telomerase activity is activated in embryonic stem cells to enable high proliferation rate of the cell. However, the telomerase activity is usually diminished after birth and the level of telomerase activity is absent in most of the somatic cells.

Fig. 4.1 shows the *TERT* promoter in the two types of cells.

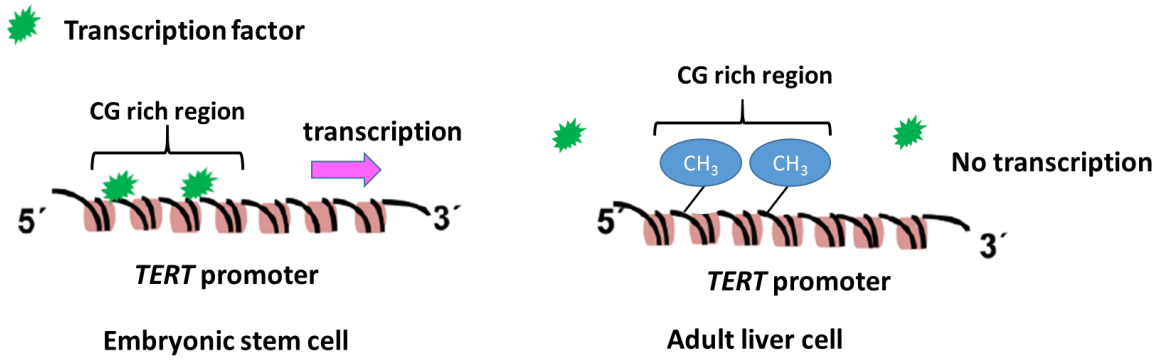


Fig. 4.1

(b) With reference to **Fig. 4.1** and your knowledge, explain why telomerase activity is absent in adult liver cells. [3]

- **DNA methylation** occur at the **CG rich region** of the TERT promoter
- which **recruits histone deacetylase** to **promote chromatin compaction**
- **Transcription factors** and **RNA polymerase** cannot access the **promoter** of *TERT,* hence prevent gene expression

(c) The process occurring in adult liver cells shown in **Fig. 4.1** also occurs in prokaryotic cells.

State how the outcome of the process in prokaryotes differs from that in adult liver cells. [1]

- DNA methylation in adult liver cell leads to **long-term inactivation of genes/turning genes** off whereas it **protects the bacteria DNA from being degraded by restriction enzymes.**

(d) Outline the roles of telomeres in eukaryotic cells. [3]

- **Protect the organism's genes from being lost with each round of DNA replication.**
- **Protect the chromosome by binding proteins that prevents the ends from joining to other chromosomes.**
- Telomeres and associated proteins **prevent the exposed staggered ends of DNA from activating the cell's monitoring system to cause apoptosis** of cell.
- Allow the **completion of DNA synthesis at the ends of eukaryotic chromosomes.**

[Total: 11]

QUESTION 5

To study the inheritance of coat colour and eye colour in deer-mice, scientists performed two crosses and the table below shows the phenotypes of the F_1 generations from these two crosses.

Cross	Parents (pure bred)	F_1 phenotype	Number of F_1 progeny
1	Black eye, coloured female X Pink eye, albino male	All black eye, coloured mice	77
2	Black eye, coloured male X Pink eye, albino female	All black eye, coloured mice	68

The F_1 generation were then interbred and the following F_2 offspring were produced:

Black eye, coloured	295
Black eye, albino	42
Pink eye, coloured	46
Pink eye, albino	33

(a) Explain the purpose of carrying out crosses 1 and 2. [2]

- A **reciprocal cross** **to determine whether** **the two gene loci** for coat colour and eye colour **are sex-linked.**
- **[Context required]** The **same F1 results** (all black eye, coloured mice) are observed suggesting that the two genes are **autosomal /not sex-linked.**

(b) Using suitable symbols, draw a genetic diagram to explain the results of F_1 cross. [5]

B represents the dominant allele for black eye
b represents the recessive allele for pink eye
A represents the dominant allele for coloured coat
a represents the recessive allele for albino

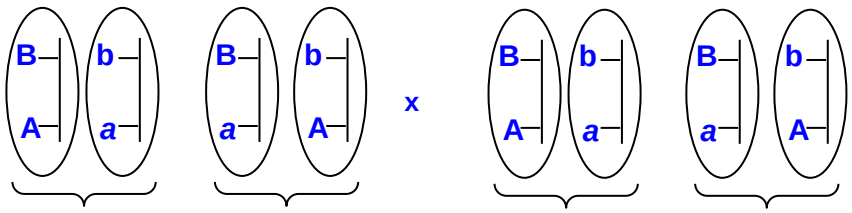
[1]

F_1 genotype (2n): $\frac{B\ \ A}{b\ \ a}$ **[1]**

F_1 phenotype: Black eye, coloured

Selfing F_1: Black eye, coloured x Black eye, coloured

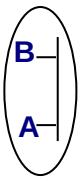
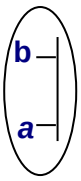
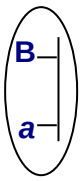
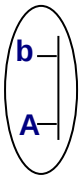
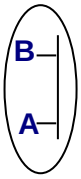
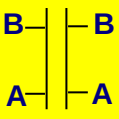
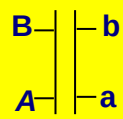
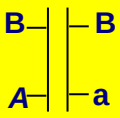
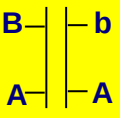
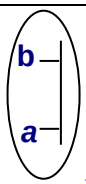
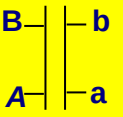
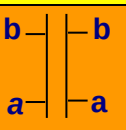
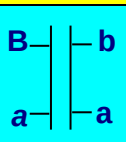
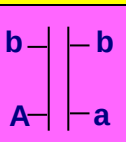
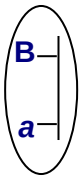
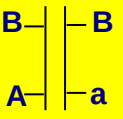
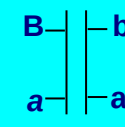
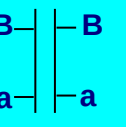
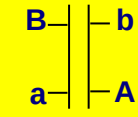
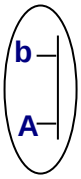
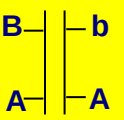
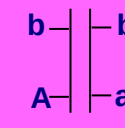
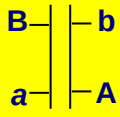
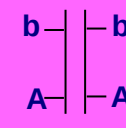
F_1 genotype: 

Gametes: 

Non-recombinant gametes (large no.) Recombinant gametes (small no.) Non-recombinant gametes (large no.) Recombinant gametes (small no.)

[1]

genotypes and phenotypes:

	 (Large no.)	 (Large no.)	 (small no.)	 (small no.)
 (Large no.)	 Black eye, coloured	 Black eye, coloured	 Black eye, coloured	 Black eye, coloured
 (Large no.)	 Black eye, coloured	 Pink eye, albino	 Black eye, albino	 pink eye, coloured
 (small no.)	 Black eye, coloured	 Black eye, albino	 Black eye, albino	 Black eye, coloured
 (small no.)	 Black eye, coloured	 pink eye, coloured	 Wide paws, hair	 pink eye, coloured

[1]

Match phenotype with genotype

F_2 phenotypes:	Black eye, coloured	pink eye, albino	Black eye, albino	pink eye, coloured
	Non-recombinant phenotypes (large numbers)		**Recombinant phenotypes (small numbers)**	
Observed no.	295	: 33	42	: 46

[1]

(c) State the expected ratio of the F_2 phenotypes if Mendelian law applies to the two gene loci. [1]

9:3:3:1

The chi-squared (χ^2) test was performed on these results, giving a calculated value for $\chi^2$of 47.527.

The χ^2 distribution table and equation to calculate χ^2 is shown below.

number of degrees of freedom (v)	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

(d) Use the calculated value of χ^2 and the table of probabilities provided in the table above, explain the conclusions drawn from the (χ^2) test. [3]

- The calculated χ^2 value of 47.527 is **greater than** the **critical value of 7.82 at 5% significance** level
- The **probability** that the **difference between expected and observed number is due to chance** is **less than 0.05**.
- Difference is **significant / not due to chance**, the observed number of 295:42:46:33 does not **conform to the expected ratio 9:3:3:1**, hence the two gene loci are **linked.**

[Total: 11]

QUESTION 6

Two groups of white mustard plants, *Sinapis alba*, were grown, one group under high illumination, the other under low illumination. When fully grown, the effect of increasing light intensity on the rate of photosynthesis in the two groups of plants was measured.

Fig. 6.1 shows the results.

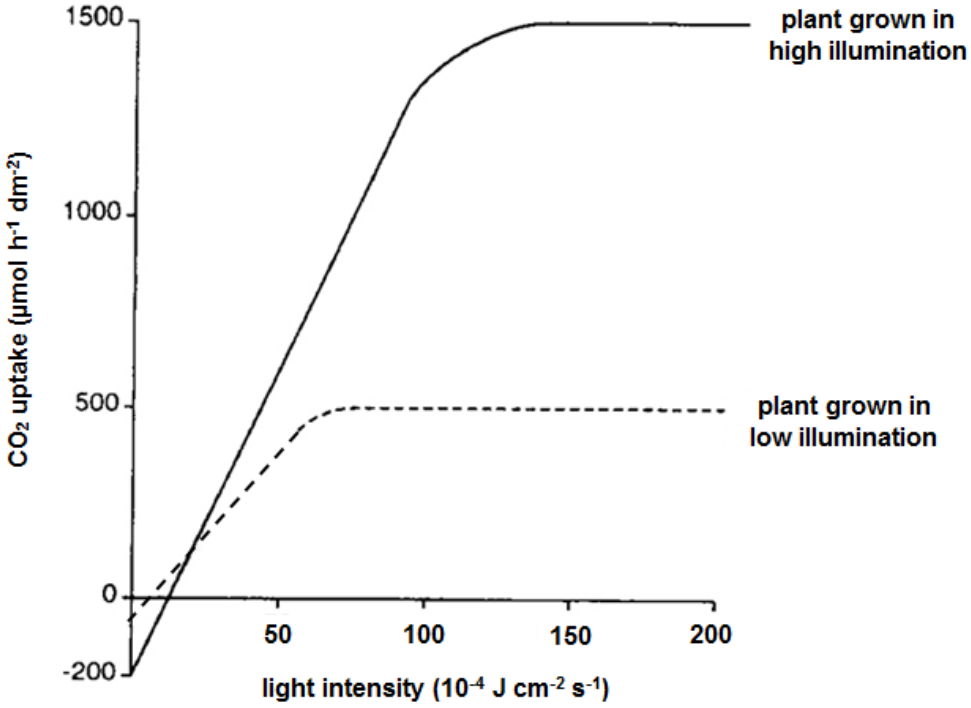


Fig. 6.1

(a) With reference to **Fig. 6.1**,

(i) state and explain the effect of light intensities above 150 x 10^{-4} $Jcm^{-2}s^{-1}$ on the rate of photosynthesis in plants grown in high illumination. [2]

- **For light intensity above 150x10^{-4} Jcm^{-2} s^{-1}, CO_2 uptake remains constant at 1500 µmol$h^{-1}dm^{-2}$.**
- **Light saturation is reached /light intensity is no longer the limiting factor.**

(ii) state with evidence, **two** ways in which the carbon dioxide uptake of both plants differ at light intensities below 50 x 10^{-4} $Jcm^{-2}s^{-1}$. [4]

Any two:

- **For light intensity between 20-50 x10^{-4} Jcm^{-2} s^{-1}, (rate of) CO_2 uptake for the plants grown in high illumination is higher than that grown in low illumination. [1]**
  - **Figures – [1]**
- **The compensation point for plants grown in high illumination occurs at a higher light intensity than those grown in low illumination or vice versa [1]**
  - **High illumination:15 x 10^{-4} Jcm^{-2} s^{-1} and Low illumination: 7x 10^{-4} Jcm^{-2} s^{-1}– [1]**

- **Below the compensation point, plants grown at high illumination give out more carbon dioxide than plants grown in low illumination. [1]**
  - **High illumination: -200 µmol $h^{-1}dm^{-2}$ and Low illumination: -50µmol$h^{-1}dm^{-2}$– [1]**

- **Below the compensation point, plants grown at high illumination give out more carbon dioxide than plants grown in low illumination. [1]**
  - **High illumination: -200 µmol $h^{-1}dm^{-2}$ and Low illumination: -50µmol$h^{-1}dm^{-2}$– [1]**

- ***(not a good answer)*** **rate of CO_2 uptake increases at a faster rate for plant grown in high illumination than plants grown in low illumination. [1]**
  - **High illumination: -200 µmol $h^{-1}dm^{-2}$ to 650 µmol $h^{-1}dm^{-2}$ and Low illumination: -50µmol$h^{-1}dm^{-2}$ to 400 µmol $h^{-1}dm^{-}$– [1]**

(b) Outline the fate of each product of photolysis in the light dependent reaction. [3]

1. Oxygen used by cells for aerobic respiration
2. Excess oxygen is released out of plant through stomata

3. Protons diffuse through ATP synthase **from thylakoid space to stroma** to generate ATP
4. protons combine with electrons from PS-I and **NADP to form NADPH**

5. Electrons are used to **replace electrons loss from PS-II**
6. Electrons are transported along **electron transport chain** by **electron carrie**rs of progressively lower energy levels
7. In cyclic photophosphorylation, **electron from PS-I goes back to PS-I**
8. In non-cyclic photophosphorylation, electrons from PS-I **combine with protons and NADP to form NADPH**

[Total: 9]

QUESTION 7

Fig. 7.1 is an electron micrograph of a section through a myelinated neurone showing the Schwann cell and axon membrane.

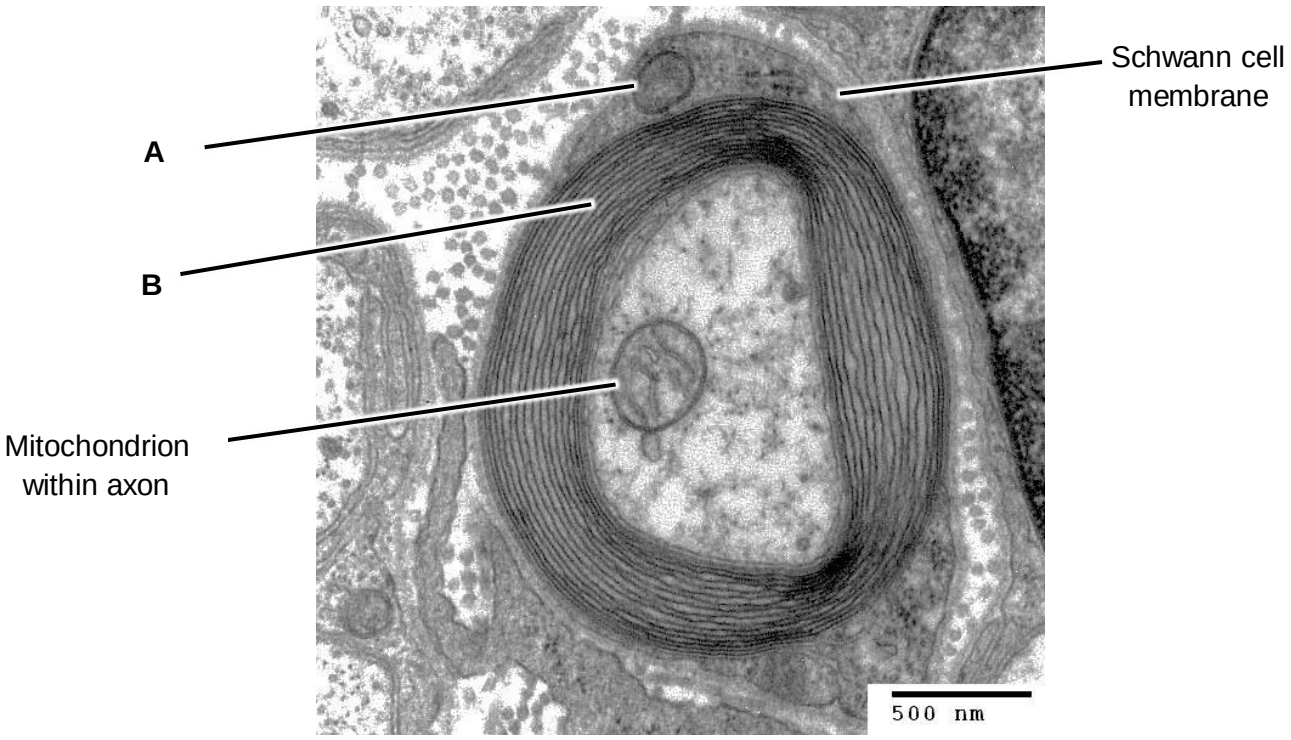


Fig. 7.1

(a) Identify the structures labelled **A** and **B**. [2]

A **Nucleus** of the Schwann cell

B **Myelin sheath**

(b) **Fig. 7.2** shows the percentage of energy used for various processes involved in the maintenance of resting potentials and in the reception and transmission of action potentials by a neuron.

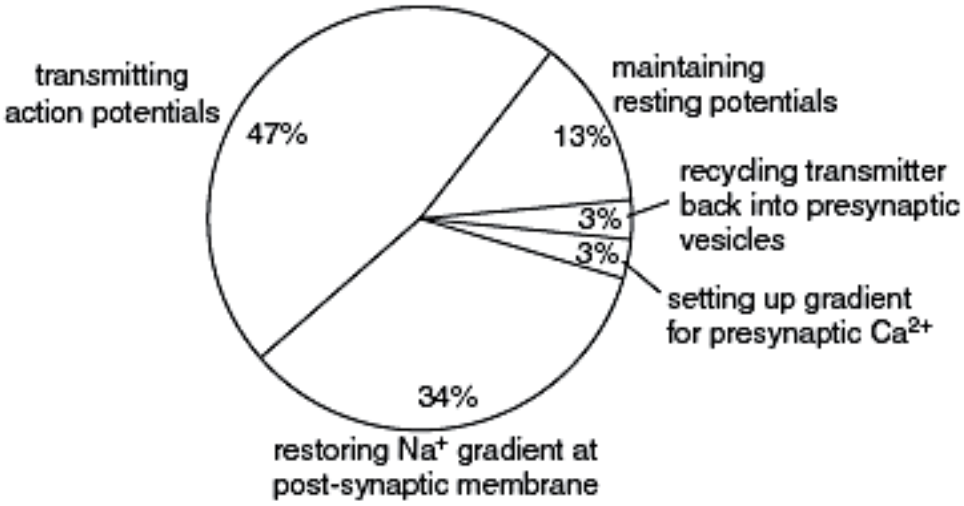


Fig. 7.2

(i) Explain why maintaining a resting potential requires energy. [2]

- Active transport of **3 sodium ions out and 2 potassium ions in** via the **sodium potassium pump**
- ..**against concentration gradient** which requires hydrolysis of **ATP**

(ii) Neurons contain large numbers of mitochondria. There are more mitochondria in each dendrite than in the axon.

With reference to **Fig. 7.2**, suggest reasons for the distribution of mitochondria. [3]

- Mitochondria is the site for **ATP synthesis**
  Restoring Na+ gradient at post-synaptic membrane uses **34% energy** which occurs in **dendrites**
- Recycling neurotransmitter **and** setting up Ca2+ gradient requires only **6% energy in terminal end of axons**

(c) Describe the role of Ca^{2+} in the passage of impulses across a synapse. [2]

- **Ca^{2+} influx into presynaptic neuron** via facilitated diffusion through voltage-gated Ca^{2+} channels
- The increase in Ca^{2+} causes **vesicles that contain neurotransmitters** move to and **fuse** with **presynaptic membrane**
- causes the **neurotransmitter to be released into the synaptic cleft** by **exocytosis**

(d) Synapses slow down the rate of transmission of nerve impulses but serve other important roles in the nervous system.

Outline two roles of synapses in the nervous system. [2]

Ensure **one-way transmission**

- **Filter out infrequent impulses**/ temporal summation
- Allow spatial summation/ convergence of impulse/ interconnection of many nerve cells
- Allow transmission of information between neuron
- Prevent overstimulation **[Total: 11]**

QUESTION 8

Mole rats, *Spalax ehrenbergi,* are mammals that live in groups in underground burrows. They are blind, and communicate with each other through sound and scent. Males make a purring call when they attempt to persuade females to mate with them.

In Israel, the mole rats found in different parts of the country all look identical. However, there are actually four different populations with different chromosome numbers, which live in different climatic regions.

Table 8.1 shows the four populations of mole rats and information about the purring calls used by the males in each population. The call of the males were analysed by measuring the number of sound pulses per second, and also the frequencies of the sounds that they made.

Chromosome number of population		52	54	58	60
Climatic region in which population lives		Cool and humid	Cool and dry	Warm and humid	Warm and dry
Purring call made by males	Mean number of pulses per second	21.0	25.3	23.9	23.2
	Mean major frequency/ kHz	595	555	583	562

Table 8.1

Researchers investigated how female mole rats from each of the four populations responded to purring calls made by males from the same population, and by males from different populations.

A female was placed midway between two loudspeakers, and recorded calls from two males were played to her simultaneously. The researchers noted which loudspeaker the female moved towards. This was repeated with many different females from each population.

The results are shown in **Table 8.2.**

Population chromosome number	Percentage of females preferring the purring call of males from their own population
52	79
54	77
58	78
60	44

Table 8.2

(a) With reference to **Table 8.2**, describe the extent to which female mole rats show a preference for the purring calls of males from their own population. [2]

- **High percentage of 79%, 77% and 78%** females from populations with **52, 54 and 58 chromosome number respectively** prefer calls from their own population
- **Low percentage of 44% of females from population with 60 chromosome number** prefer calls from their own population

(b) With reference to the data in both **Table 8.1** and **Table 8.2**, discuss whether these four populations of mole rats should be classified as different species. [4]

- **Yes**
- mole rats with different chromosome numbers
- **cannot interbreed to form fertile and viable offspring**
- as not all chromosomes will be able to pair up in meiosis/prophase 1/ idea of producing offspring with odd no. of chromosome (OWTTE)
- Geographically isolated/ live in different habitats so unlikely to interbreed
- Most females prefer males from their own population due to differences in mating call

The phylogenetic relationship of seven genera of mole rats was investigated using nucleotide sequences of the *12S rRNA* gene obtained from mitochondrial DNA.

Fig. 8.1 shows a phylogenetic tree of the mole rats based on this *rRNA* gene nucleotide sequence data.

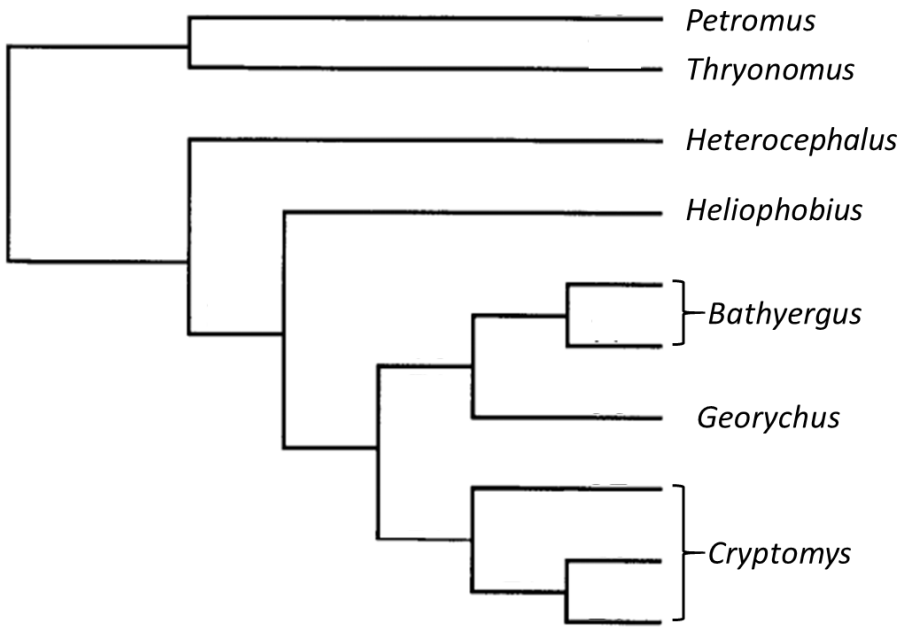


Fig. 8.1

(c) Describe the advantages of using nucleotide data such as the *12S rRNA* gene in classifying the mole rats. [3]

- The mole rats share the **same kind of genetic material** — **DNA**. Hence it is a good basis of comparison.
- It is **objective** as **homologous nucleotide sequence** can be **compared**. It is also **quantitative** as the **differences** can be **counted** and subjected to **statistical analysis.**
- Nucleotide sequence comparison is more complete as it takes into consideration of **silent mutations and changes in non-coding sequences** (not expressed in phenotype)…
- The **rate of accumulation of mutation** in the gene coding for 12s RNA occurred at a **constant rate** through time
- The number of nucleotide differences can be used as a gauge to estimate when **two species diverged from a common ancestor**
- *12S rRNA* gene is found on mtDNA which **lacks germline recombination** (crossing over, independent assortment). Thus, variation in the cytochrome b gene sequence is largely by mutation.
- The probability of recovery of mtDNA from very small or degraded biological samples is higher than the one of nuclear DNA, because the mitochondrial DNA molecules exist in **thousands of copies per cell**, while nuclear DNA has only two copies per cell.
- mtDNA has a **high level of variability** (due to high rate of mutation) in the **non-coding sequence** (control region) which can be used to elucidate phylogenetic relationships among **recently diverged species**. This high rate of mutation of mtDNA is due to the absence of DNA repair mechanism in mitochondria.

[Total: 9]

QUESTION 9

(a) Describe the role of vesicles in a cell. [6]

1. For transport of proteins from **Endoplasmic Reticulum** to **Golgi Apparatus**
2. For transport of proteins from **Golgi Apparatus** to **Cell Surface Membrane**
3. For transport of proteins from **Golgi Apparatus** to other cellular organelles or destinations
4. For **fusion** of vesicle with **cell surface membrane** which results in **replenishment of** cell **surface membrane**
5. For **fusion** of transport vesicle with GA which results in **replenishment of Golgi Apparatus membrane**
6. For **enclosing** foreign particles by the process of **endocytosis**
7. Functions as **lysosomes that store hydrolytic enzymes [at least 1 function** of lysosome]
8. **Cellulose**-containing vesicles fuse to form the **cell plate** during cytokinesis in plant cells
9. Named examples, e.g. insulin (secreted), G-protein coupled receptor (embedded in CSM), proton pumps (embedded in lysosomal membrane), neurotransmitters (exocytosis).

(b) Describe one causative factor of cancer and explain how this factor increases the chances of cancerous growth. [6]

1. **ONE Causative Factor:** Excessive **UV radiation / chemical carcinogens / viruses / inherited genetic factors**

2. Describe: viruses may **insert** their **genetic material** / DNA into the **host cell genome** may disrupt proto-oncogenes or tumour-suppressor genes.

   Describe: Excessive UV radiation / ionising radiation may cause **mutations** to proto-oncogenes or tumour-suppressor genes.

   Describe: **Exposure** to **carcinogens** (chemicals that cause cancer) e.g. ethidium bromide, benzo(a)pyrene in cigarette smoke, sodium nitrite in preserved foods may cause mutations

   Describe: An individual inheriting an **oncogene** (a mutated proto-oncogene) or a **mutant** allele of a **tumor-suppressor gene** will be one step closer to accumulating the necessary mutations for cancer development.

3. **Mutated proto-oncogenes** code for **hyperactive proteins** that cause uncontrolled cell division.
4. **Mutated tumour suppressor** genes code for **non-functional proteins** that cause uncontrolled cell division.
5. Cancer is a **multi-step process**, which requires **accumulation of mutations in multiple genes**.
6. Mutations in proto-oncogenes and tumour-suppressor genes can cause cell to **bypass cell cycle checkpoints/ dysregulation** of checkpoints.
7. **Damaged DNA / mutations are not repaired /** arrested at the cell cycle checkpoints**.**

8. leading to the **accumulation of mutations in a <u>SINGLE</u> cell,** resulting in formation of a cancerous cell that undergoes **uncontrolled cell division**.

(c) Describe the differences between the control of gene expression in prokaryotic and eukaryotic cells. [8]

	Eukaryotic genome	Prokaryotic genome
At chromosomal level		
	1. **Histone modifications** to regulate how compact the DNA region is	**No histone modification** as DNA not associated with histones
At transcriptional level		
Control at Promoter	2. **One promoter** for **each gene**	**One promoter** occurs for **each operon** which **consist of several functionally related structural genes**
Induction/ repression in response to external stimuli	3. In response to external stimuli, **transcription factors** may bind to regulatory sequences and activate or silence transcription	In response to external stimuli, **regulatory proteins** bind to control regions for each operon, inducing or repressing transcription
At post-transcriptional level		
	4. **Transcription and translation processes are separated** due to presence of nuclear membrane 5. **post transcriptional modifications** (addition of 5'cap, 3' poly-A tail, splicing) occur	**Transcription and translation occur simultaneously** due to the **absence of a nuclear membrane** **No controls at post-transcriptional level**
At translational level		
	6. **repressor proteins** bind to 5' UTR and blocks translation	**No repressor proteins** bind to the 5' region of mRNA, translation not blocked
At post-translational level		
	7. **degradation of proteins** by ubiquitin 8. **cleavage may occur for some proteins**	**Ubiquitin is not involved in degradation of proteins** **No cleavage of proteins**

[Total: 20]

QUESTION 10

(a) Describe the structure of collagen and how it is related to its function. [8]

1. **Tropocollagen** is formed when **three** collagen **polypeptide chains** wound around each other to give a **triple helix**.
2. Each collagen polypeptide chain is in the shape of a **loosely wound left-handed helix** that wind around the other two.
3. The three strands are linked together by **hydrogen bonds** formed between peptide N-H group of glycine and peptide C=O group of other amino acids on the other strands.
4. The sequence of amino acids of each strand is usually a repeat of
   Glycine – Proline – X, or
   Glycine – X – Hydroxyproline where X is any other amino acids except glycine
5. The presence of **glycine** at every third amino acid within each polypeptide chain allows **close packing** of the triple helix to form a **tight coil**.
6. Each complete triple helix of tropocollagen interacts with other tropocollagen molecules running parallel to each other by forming **covalent bonds** between the **lysines** in chains lying next to each other.
7. These cross-links hold many tropocollagen molecules side by side, forming **fibrils**, giving rise to **high tensile strength** (mark once for high tensile strength).
8. In collagen **fibrils**, tropocollagens lie **parallel** with **staggered ends,** which would permit them to **overlap** with the tropocollagens in adjacent fibrils.
9. Aggregation of overlapping collagen **fibrils** form strong collagen **fibers.**
10. **[Function]** Hence collagen is able to **provide structural support** for skin, tendons, cartilage, bones, teeth and connective tissue of blood vessels.

(b) Explain why antibiotic resistance spreads so rapidly among bacteria. [6]

High rate of DNA replication

- Idea that bacteria reproduces rapidly/ frequent DNA replication
- Higher chances for mutation

Mutation transferred to another bacteria by genetic recombination

- Mutation may be on plasmid which can be transferred to the recipient bacterial cell via conjugation ; brief description of **conjugation** [max 2]
- Describe process of **transformation** [max 2]
- Describe process of **transduction** [max 2]

Natural selection

- Those bacteria with antibiotic resistance gene are at **selective advantage** when subjected to antibiotic (selection pressure)
- ..able to survive to reproduce and passed on the mutation/ antibiotic resistance gene to large no. of offspring

(c) Describe the main differences between glucagon and insulin signalling in liver cells. [6]

Stages	Insulin	Glucagon
Reception	1. Tyrosine kinase receptor;	1. G-protein coupled receptor
Transduction	2. Dimerization 3. Phosphorylation of tyrosine residues 4. Activation of relay proteins	2. Receptor activated and changes shape 3. Activates G protein 4. Activation of adenyl cyclase to form cAMP/activates kinases
Response	5. Facilitates transport of glucose into cells 6. Increasing number of glucose carriers 7. Synthesis of glycogen from glucose	5. Facilitates release of glucose out of cells 6. No Increase in number of glucose carriers 7. Breakdown of glycogen by glycogen phosphorylase

[Total: 20]

• END OF PAPER 2 •

JC2 Preliminary
Examinations 2016 Higher 2

CANDIDATE NAME	
CIVICS GROUP	1 5 S
INDEX NUMBER	

H2 BIOLOGY

9648/03

Applications Paper and Planning Question
Paper 3
Additional Materials: Answer papers

20 September 2016
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough workings.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

At the end of the examination,
1. Fasten all your work securely together.
2. Hand in the following separately:
   - Structured questions 1 – 3
   - Planning question
   - Essay question

The number of marks is given in brackets [ ] at the end of each question or part question.

For examiner's Use	
1	/ 13
2	/ 13
3	/ 14
4 Planning	/ 12
5 Essay	/ 20
Total	**/ 72**

This paper consists of **12** printed pages.

[Turn over]

Answer **all** questions.

For Examiner's Use

QUESTION 1

ABL1 is a proto-oncogene that encodes a protein tyrosine kinase involved in a variety of cellular processes, including cell division. A researcher intended to mass produce ABL1 protein tyrosine kinase using bacterial cells. He obtained *ABL1* cDNA from the cDNA library and the complete sequence of *ABL1* cDNA non-template strand is shown in **Fig. 1.1**. The start and stop triplets are bolded.

```
5' 1   CCTATTATTACTTTATGGGGCAGCAGCCTGGATCCGT----------
  61   ----------
 121   ----------GCATCTGACTTTG
 181   AGCCTCAGGG TCTGAGTGAAGCTTCT 3'
```

Fig. 1.1

(a) Explain why the gene of interest is obtained from cDNA library instead of genomic DNA library. [2]

……

……

……

……

The plasmid pUC18, was first chosen for the cloning of *ABL1* cDNA. **Fig. 1.2a** shows a diagram of the plasmid pUC18 and the position of the restriction sites found in the plasmid.

Fig. 1.2b shows two restriction sites commonly used in genetic engineering.

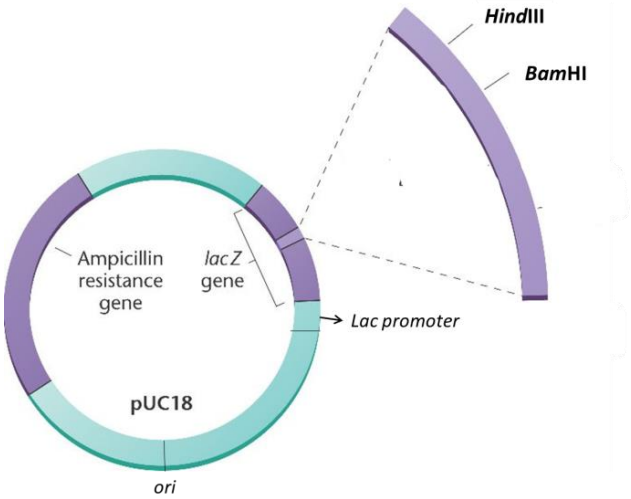


Fig. 1.2a

Fig. 1.2b

(b) With reference to **Fig. 1.1 and Fig. 1.2**, comment on the effectiveness of using pUC18 for ABL1 protein production. [3]

For Examiner's Use

……

……

……

……

……

……

The researcher found that the *ABL*1 cDNA is present in low copy number in the cDNA library. Hence, he carried out PCR to amplify the *ABL1* cDNA.

(c) Suggest two reasons why the total amount of amplified *ABL1* cDNA did not increase between the 30th cycle and the 40th cycle. [2]

1. ……

……

2. ……

……

An alternative cloning technique called **TA** cloning shown in **Fig. 1.3** can also be used to clone the *ABL1* cDNA. The *Taq* DNA polymerase used in PCR has a non-template dependent activity which preferentially adds a single adenine nucleotide to the 3'-ends of a double stranded DNA molecule. This results in PCR product with 3'-A overhangs. This enables the *ABL1* cDNA to be inserted into a plasmid designed to have 3'-T overhangs.

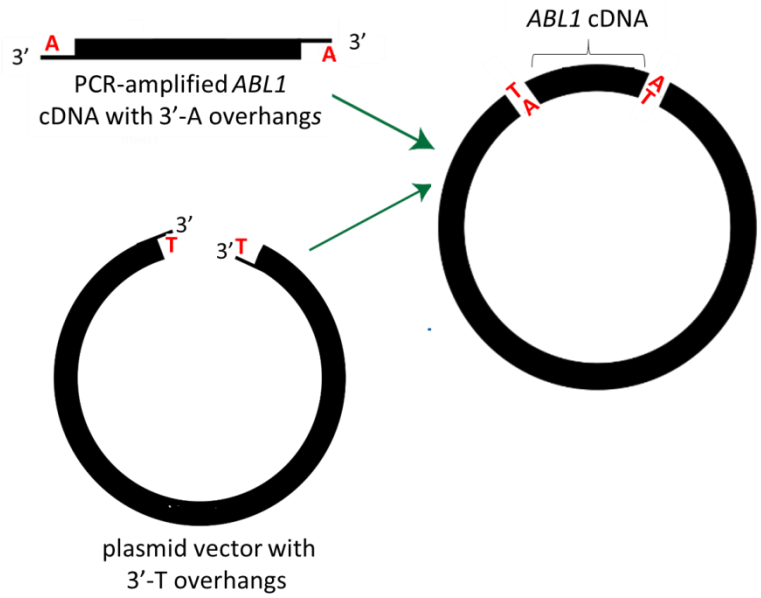


Fig. 1.3

(d) (i) With reference to **Fig. 1.3**, describe how the PCR-amplified *ABL1* cDNA can be inserted into the plasmid using **TA** cloning technique. [4]

For Examiner's Use

……

……

……

……

……

……

……

……

(ii) Suggest one advantage and one disadvantage of using **TA** cloning. [2]

Advantage:

……

……

Disadvantage:

……

……

[Total: 13]

QUESTION 2

For Examiner's Use

Plants have developed defence mechanisms against pathogens such as bacteria, fungi and viruses. Chemicals released by these pathogens can trigger a defence response in infected plant cells. For example, the production of hydrogen peroxide (H_2O_2) which reacts with pathogen membranes and cellular chemicals eventually kills both the cell and pathogen.

The *OSRac1* gene from another plant species was isolated and introduced into a number of rice plant (*Oryza spp.*) lines to study its role in disease resistance of plants to blast fungus. Experiments were carried out to see if the *OSRac1* gene was part of the signalling pathway for hydrogen peroxide production. A control (**C**) and four other genetically modified rice plant lines (**A1**, **A2**, **D1** and **D2**) grown *in vitro* from calluses were exposed to chemicals known to initiate a defence response by producing hydrogen peroxide. **A1** and **A2** are rice plants with the *OSRac1* gene always turned on. **D1** and **D2** are rice plants with the *OSRac1* gene suppressed. The results are shown in the **Fig. 2.1**.

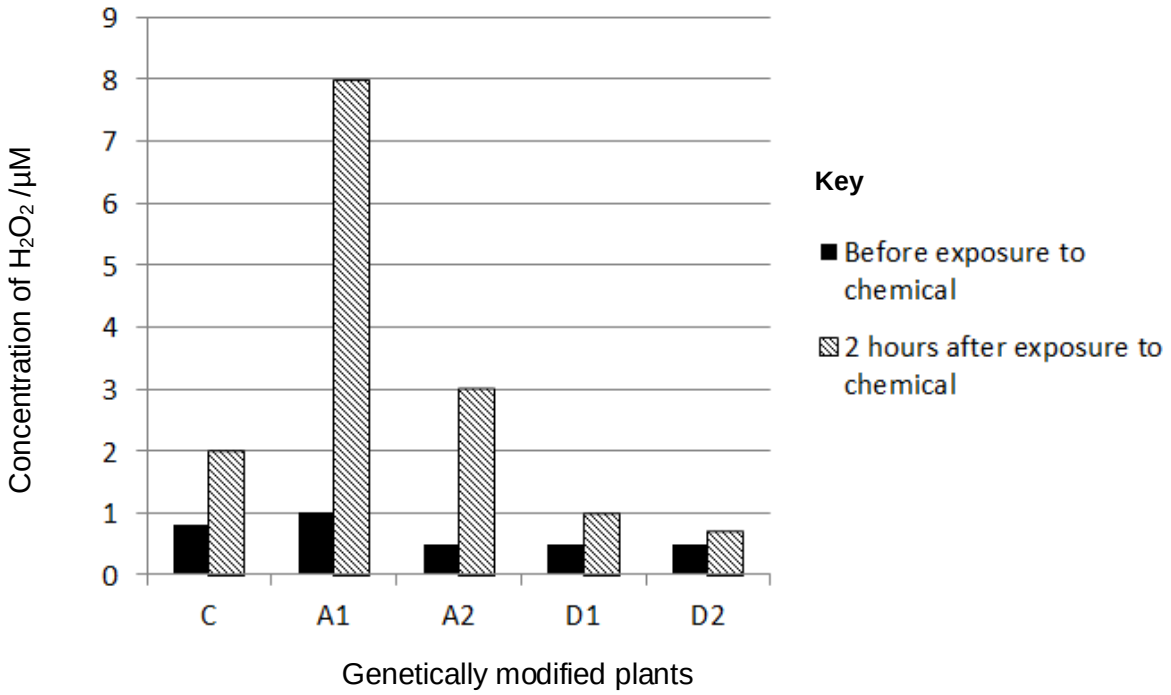


Fig. 2.1

(a) Describe how calluses are obtained from rice plants. [3]

……

……

……

……

……

……

(b) With reference to **Fig. 2.1**, compare the **change in H_2O_2 production** between the control and genetically modified plants two hours after the chemical was applied. [2]

For Examiner's Use

……..

……..

……..

……..

……..

(c) Evaluate whether the data supports the hypothesis that *OSRac1* gene is involved in disease resistance. [2]

……..

……..

……..

……..

Rice blast caused by the fungal pathogen is a destructive disease of rice. The use of blast resistance genes is an effective way to control the fungal disease in rice and to reduce losses in crop yield.

For Examiner's Use

Recently, researchers identified a known genetic marker that is tightly linked to the blast resistance genes in some fungal resistant crops. This allows the identification of crops with blast resistance and subsequent cloning of transgenic rice with the blast resistance gene.

In a rice breeding programme, researchers wanted to identify the blast resistant crops from those that are susceptible to blast.

(d) Using the information provided, describe how RFLP analysis can help to distinguish between blast resistant crops and those that are susceptible to blast. [6]

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

[Total: 13]

QUESTION 3

For Examiner's Use

(a) Describe how the normal copy of a gene can be introduced to a patient's cells via non-viral method. [3]

……

……

……

……

……

……

Type 1 diabetes is a condition where an individual's Islet cells cannot produce insulin in response to high blood glucose levels. Patients usually are dependent on insulin injections.

Transplanting Islets from donors has been studied as a form of treatment for Type I diabetes for over three decades.

Islet cells are usually encapsulated in alginate microspheres before transplanting them into patients. The alginate microsphere creates a barrier between the donor cells and the recipient's cells.

Fig. 3.1 shows some Islet cells encapsulated in an alginate microsphere.

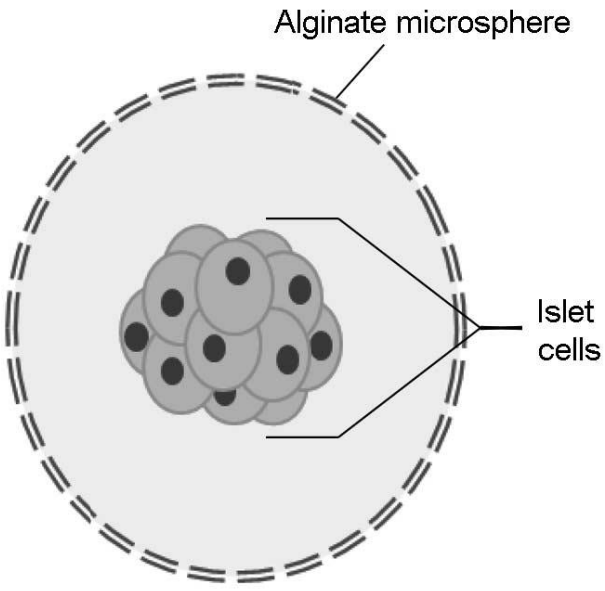


Fig. 3.1

(b) Suggest why Islet cells were encapsulated before they were transplanted into a patient. [1]

……

……

Patients transplanted with human Islet cells obtained from deceased individuals can be made insulin independent for around 5 years using the Islet encapsulation treatment. However, this approach is limited because of the scarcity and quality of donor Islet cells.

For Examiner's Use

(c) Suggest why Islet encapsulation treatment lasts only approximately 5 years. [2]

……

……

……

……

(d) Researchers have also looked into producing human insulin-producing beta cells from stem cells.

A recent study in 2014 used a human embryonic stem cell line (HUES8) and a human induced pluripotent stem cell (hiPSC) line to develop two types of human insulin-producing beta cells called HUES8 SC-β and hiPSC SC-β respectively to overcome the problem of scarcity.

The human induced pluripotent stem cells were derived from fully differentiated adult somatic cells as shown in **Fig. 3.2.**

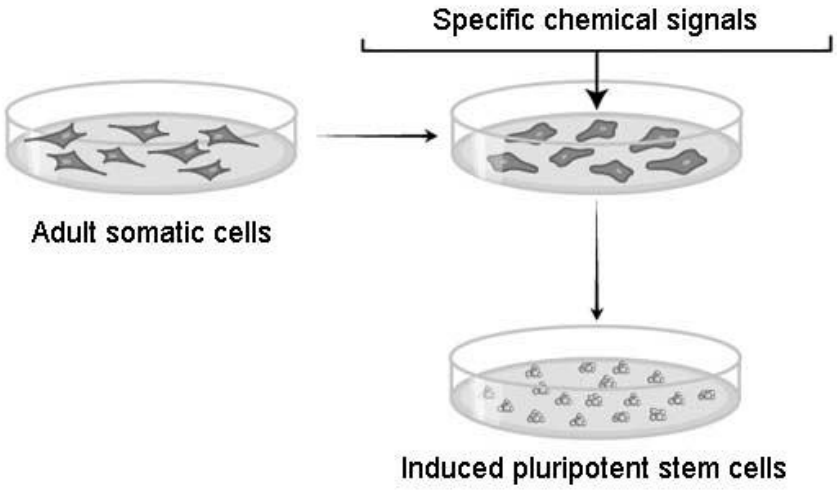


Fig. 3.2

(i) Explain why fully differentiated somatic cells can be induced to become pluripotent. [2]

……

……

……

……

(ii) State one ethical issue related to stem cell research and explain how using induced pluripotent stem cells would address this issue. [2]

For Examiner's Use

……

……

……

……

(e) Trials have been done by transplanting HUES8 SC-β cells and hiPSC SC-β cells into diabetic mice using alginate microsphere encapsulation. Human insulin produced by the mice was measured following a high carbohydrate meal.

The results of this study were recorded in **Table 3.1**.

Type of beta cell transplanted into diabetic mice	Mean concentration of human insulin secreted ± standard deviation / μg per ml of blood
HUES8 SC-β cells	2.3 ± 0.2
hiPSC SC-β cells	2.2 ± 0.3
Normal human beta cells	2.1 ± 0.9

Table 3.1

(i) Compare the secretion of insulin by these three types of transplanted cells. [3]

……

……

……

……

……

……

(ii) Explain the purpose of the normal human beta cells. [1]

……

……

[Total: 14]

QUESTION 4 – Planning question

For Examiner's Use

You are required to plan, but not carry out, an experiment to investigate the effect of temperature on the rate of respiration in mung beans.

Germination of mung beans can be initiated by soaking the seeds overnight. The mung beans can then be placed into a simple respirometer (**Fig. 4.1**) to measure the rate of respiration by measuring oxygen uptake of the seeds. Soda lime pellets absorb any carbon dioxide produced by the germinating seeds. As oxygen is taken up during respiration, the drop of coloured liquid introduced in the capillary tube by capillary action is displaced.

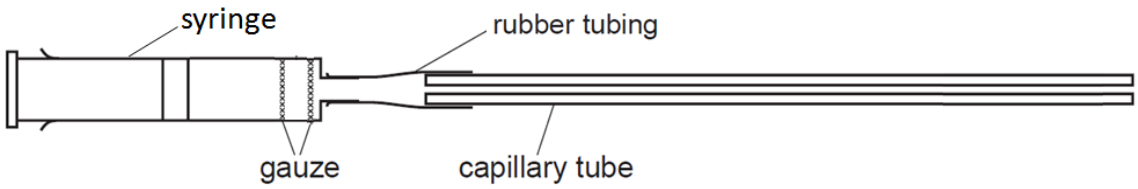


Fig. 4.1: A respirometer

You must use the items from this list:

- 200 mung beans of equal size that have been soaked for 24 hours
- Soda lime pellets 

- Syringes
- Rubber tubing connected to glass capillary tube with 1mm bore diameter
- Beaker of coloured liquid
- Ruler marked in mm
- Paper towels
- Stop watch
- Thermostatically controlled incubator
- Other available laboratory apparatus and equipment

Your plan should have a clear and helpful structure to include:

- a description of the method used including the scientific reasoning behind the method,
- an explanation of the dependent and independent variables involved,
- relevant, clearly labelled diagrams,
- how you will record your results and ensure that they are as accurate and as reliable as possible,
- proposed layout of results tables and graphs with clear headings and labels,
- the correct use of technical and scientific terms,
- relevant risks and precautions taken

[Total: 12]

Free-response question

For Examiner's Use

Write your answer to this question on the separate answer paper provided.

Your answer:

- should be illustrated by large, clearly labeled diagrams, where appropriate;
- must be in continuous prose, where appropriate;
- must be set out in sections **(a), (b)** etc., as indicated in the question

QUESTION 5

(a) Discuss the detrimental environmental and economic effects of growing genetically-modified herbicide resistant crops. [6]

(b) Discuss the ethical and social issues of the Human Genome Project. [6]

(c) Describe how a genetic condition like SCID may be treated with viral gene therapy and discuss the potential limitations of this kind of treatment. [8]

[Total: 20]

• END OF PAPER 3 •

JC2 Preliminary Examinations
2016 Higher 2

CANDIDATE NAME	
CIVICS GROUP	1 5 S
INDEX NUMBER	

H2 BIOLOGY

9648/03

Applications Paper and Planning Question
Paper 3
Additional Materials: Answer papers

20 September 2016
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough workings.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

At the end of the examination,
1. Fasten all your work securely together.
2. Hand in the following separately:
   - Structured questions 1 – 3
   - Planning question
   - Essay question

The number of marks is given in brackets [ ] at the end of each question or part question.

ANSWER SCHEME

For examiner's Use	
1	/ 13
2	/ 13
3	/ 14
4 Planning	/ 12
5 Essay	/ 20
Total	**/ 72**

This paper consists of __ printed pages.

[Turn over]

Answer **all** questions.

QUESTION 1

ABL1 is a proto-oncogene that encodes a protein tyrosine kinase involved in a variety of cellular processes, including cell division. A researcher intended to mass produce ABL1 protein tyrosine kinase using bacterial cells. He obtained *ABL1* cDNA from the cDNA library and the complete sequence of *ABL1* cDNA non-template strand is shown in **Fig. 1.1**. The start and stop triplets are bolded.

```
5' 1   CCTATTATTACTTT ATG GGGCAGCAGCCTGGATCCGT----------
  61   ----------
 121   ----------GCATC TGA CTTTG
 181   AGCCTCAGGG TCTGAGTGAAGCTTCT 3'
```

Fig. 1.1

(a) Explain why the gene of interest is obtained from cDNA library instead of genomic DNA library. [2]

- cDNA library contains the *ABL1* gene **without introns** while genomic DNA library contains *ABL1* gene **with introns**
- Thus *ABL1* can be successfully **expressed/ used to synthesise functional protein** by bacteria.

The plasmid pUC18, was first chosen for the cloning of *ABL1* cDNA. **Fig. 1.2a** shows a diagram of the plasmid pUC18 and the position of the restriction sites found in the plasmid.

Fig. 1.2b shows two restriction sites commonly used in genetic engineering.

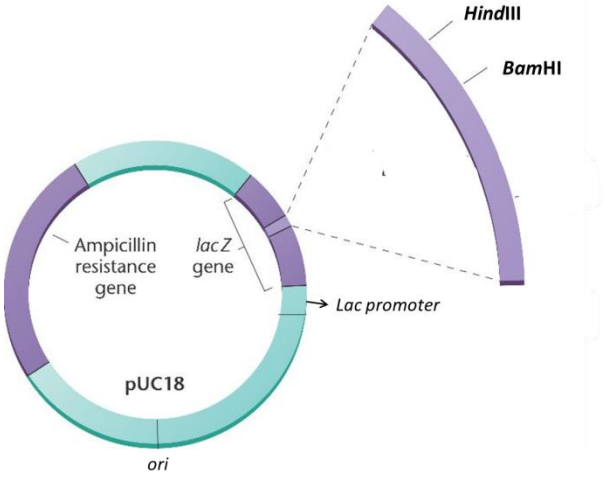


Fig. 1.2a

Fig. 1.2b

(b) With reference to **Fig. 1.1 and Fig. 1.2**, comment on the effectiveness of using pUC18 for ABL1 protein production. [3]

- **Ineffective**
- The ***BamH1* restriction site** is **downstream of the start codon** in *ABL1* cDNA (OWTTE) and ***HindIII*** restriction site is **downstream of stop codon**
- Hence the **cDNA cloned** into the plasmid will be **incomplete (OWTTE)** and **non-functional proteins** will be produced.

The researcher found that the *ABL*1 cDNA is present in low copy number in the cDNA library. Hence, he carried out PCR to amplify the *ABL1* cDNA.

(c) Suggest two reasons why the total amount of amplified *ABL1* cDNA did not increase between the 30th cycle and the 40th cycle. [2]

- Nucleotides are used up
- Primers are used up
- *Taq* DNA polymerase gradually becomes denatured

An alternative cloning technique called **TA** cloning shown in **Fig. 1.3** can also be used to clone the *ABL1* cDNA. The *Taq* DNA polymerase used in PCR has a non-template dependent activity which preferentially adds a single adenine nucleotide to the 3'-ends of a double stranded DNA molecule. This results in PCR product with 3'-A overhangs. This enables the *ABL1* cDNA to be inserted into a plasmid designed to have 3'-T overhangs.

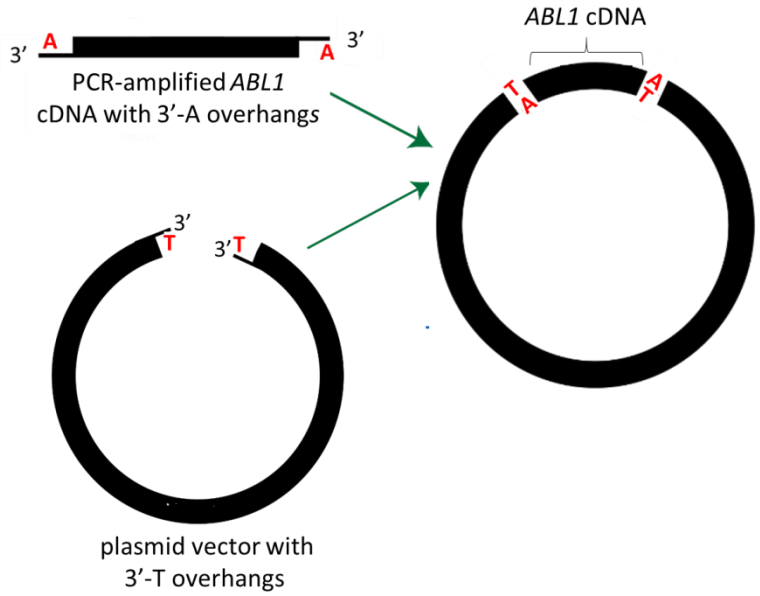


Fig. 1.3

(d) (i) With reference to **Fig. 1.3**, describe how the PCR-amplified *ABL1* cDNA can be inserted into the plasmid using **TA** cloning technique. [4]

- PCR products of *ABL1* cDNA contain 3'-A overhangs and the plasmid have **3'-T overhang**
- **Mix** the PCR products with the plasmid
- Anneal by **complementary base pairing between A and T** through formation of hydrogen bonds
- **DNA ligase** seals the sugar-phosphate backbone by forming **phosphodiester bonds**

(ii) Suggest one advantage and one disadvantage of using **TA** cloning. [2]

Advantage:

- Allows cloning of GOI that does not have restriction sites / do not require the use of restriction enzymes
- Prevents reannealing of plasmid via complementary base pairing

Disadvantage:

- **Does not allow directional insertion** of GOI (OWTTE), hence bacteria transformed with recombinant plasmid may produce wrong/non-functional proteins.

[Total: 13]

QUESTION 2

Plants have developed defence mechanisms against pathogens such as bacteria, fungi and viruses. Chemicals released by these pathogens can trigger a defence response in infected plant cells. For example, the production of hydrogen peroxide (H_2O_2) which reacts with pathogen membranes and cellular chemicals eventually kills both the cell and pathogen.

The *OSRac1* gene from another plant species was isolated and introduced into a number of rice plant (*Oryza spp.*) lines to study its role in disease resistance of plants to blast fungus. Experiments were carried out to see if the *OSRac1* gene was part of the signalling pathway for hydrogen peroxide production. A control (**C**) and four other genetically modified rice plant lines (**A1**, **A2**, **D1** and **D2**) grown *in vitro* from calluses were exposed to chemicals known to initiate a defence response by producing hydrogen peroxide. **A1** and **A2** are rice plants with the *OSRac1* gene always turned on. **D1** and **D2** are rice plants with the *OSRac1* gene suppressed. The results are shown in the **Fig. 2.1**.

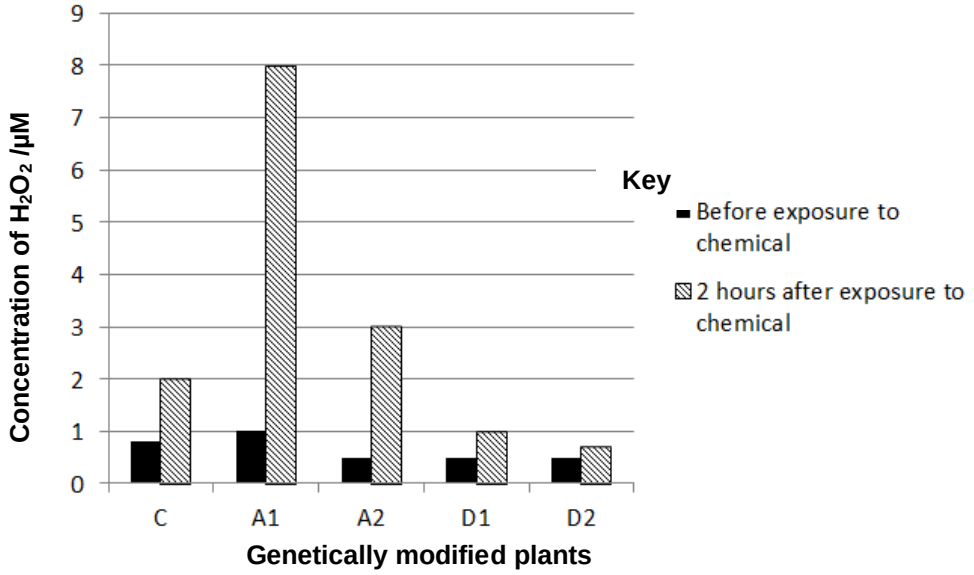


Fig. 2.1

(a) Describe how calluses are obtained from rice plants. [3]

- Surface of **explants** from rice is **sterilized** using dilute **sodium hypochlorite**.
- Rice explants are **aseptically** transferred to **sterile** culture vessels **containing nutrients** and **intermediate auxin:cytokinin ratio**
- …to **induce callus formation** by **mitosis**.

(b) With reference to **Fig. 2.1**, compare the **change in H_2O_2 production** between the control and genetically modified plants two hours after the chemical was applied. [2]

- **A1 and A2** showed a **higher increase** in H_2O_2 production of **8 times and 6 times respectively** as compared to **control** which showed an increase in H_2O_2 production of **2.5 times**
  OR
  A1 and A2 showed a **higher increase** in H_2O_2 production **by 700% and 500% respectively** as compared to **control** which showed an increase in H_2O_2 production of **150%**
- **D1 and D2** which showed a **lower increase in H_2O_2 production of 2.0 and 1.4 times** as compared to **control** which showed an increase in H_2O_2 production of **2.5 times**

OR

- **D1 and D2** which showed a **lower increase in H_2O_2 production by 100% and 40%** as compared to **control** which showed an increase in H_2O_2 production of **150%**

(c) Evaluate whether the data supports the hypothesis that *OSRac1* gene is involved in disease resistance. [2]

- **Supported** [1] ***[mark awarded only if full explanation is given]***

- **Both A1 and A2 genetically modified plants** with *OSRac1* gene always turned on showed **greater change in the number of times** of **H_2O_2 production** so hypothesis is supported.
  OR
- **Both D1 and D2 genetically modified plants** with *OSRac1* gene suppressed showed **smaller change in the number of times** of **H_2O_2 production** so hypothesis is supported.

Rice blast caused by the fungal pathogen is a destructive disease of rice. The use of blast resistance genes is an effective way to control the fungal disease in rice and to reduce losses in crop yield.

Recently, researchers identified a known genetic marker that is tightly linked to the blast resistance genes in some fungal resistant crops. This allows the identification of crops with blast resistance and subsequent cloning of transgenic rice with the blast resistance gene.

In a rice breeding programme, researchers wanted to identify the blast resistant crops from those that are susceptible to blast.

(d) Using the information provided, describe how RFLP analysis can help to distinguish between blast resistant crops and those that are susceptible to blast. [6]

1. DNA samples of blast resistant and susceptible crops are cut with the **same specific restriction enzyme** to generate **DNA fragments of different lengths**

2. **Restriction fragments** are subjected to **gel electrophoresis** where the fragments are separated according to **molecular weight/size**

10. **larger DNA fragments travel slower and smaller fragments travel faster.**

3. DNA being **negatively charged** due to the presence of phosphate group, moves towards the **anode** / positive end of the electric field.

4. A **DNA ladder** is loaded in another well to calibrate the **size of DNA fragments**.

5. Add bromophenol blue and glycerol with purpose given

6. (a) Southern blot and Nucleic acid hybridization are carried out .. **sodium hydroxide** denature double-stranded DNA to **single-stranded DNA**…

(b) …using a **radioactively-labelled DNA/RNA probe complementary to the tightly linked RFLP marker**

7. DNA bands of interest are detected using **autoradiography**

8. **Analyze and compare** the **unique band patterns of DNA** of the blast resistant and susceptible crops.

9. **[idea of ..]** The RFLP variant that is linked to the resistant allele will give a different band pattern to the RFLP variant that is linked to the susceptible allele.

[Total: 13]

QUESTION 3

(a) Describe how the normal copy of a gene can be introduced to a patient's cells via non-viral method. [3]

Mention any **one** of the methods:

Liposome method

- **Cationic liposomes** made of **positively charged** lipids are created.
- Positively charged liposomes are attracted to **negatively charged** recombinant plasmid DNA, forming **liposome-DNA complexes**.
- The liposome-DNA complexes are then **introduced directly into the target cells via endocytosis.**

Cationic polymer

- **Cationic polymers** designed to be able to **bind to the receptors** on the **target cells** are used.
- **Positively-charged** cationic polymer is attracted to **negatively-charged** recombinant DNA plasmid, forming a **polymer-DNA complex/ polyplexes**.
- The polyplexes bind to receptors on the target cells in culture, hence allowing the **uptake** of the complex by **receptor mediated endocytosis** forming endosomes.

Direct Injection and Electroporation

- The **normal allele** is inserted into a **DNA plasmid** to form a **recombinant plasmid DNA**.
- The recombinant plasmid DNA is **injected directly** into the tissue /**in vivo** technique
- The target cells are subjected to **electrical current** which **increases** the **permeability** of the membrane for the cells to take up DNA plasmids.

Gene gun

- The **normal allele** is inserted into a **DNA plasmid** to form a **recombinant plasmid DNA**.
- The recombinant plasmid DNA is coated onto **microscopic gold / tungsten particles**
- A **gene gun** is used to accelerate these particles towards the target cells in culture/ ex vivo
- These particles **penetrate** the **plasma membrane** of the target cells and deliver the DNA into the **nucleus**

Type 1 diabetes is a condition where an individual's Islet cells cannot produce insulin in response to high blood glucose levels. Patients usually are dependent on insulin injections.
Transplanting Islet cells from donors has been studied as a form of treatment for Type I diabetes for over three decades.
Islet cells are usually encapsulated in alginate microspheres before transplanting them into patients. The alginate microsphere creates a barrier between the donor cells and the recipient's cells.

Fig. 3.1 shows some Islet cells encapsulated in an alginate microsphere.

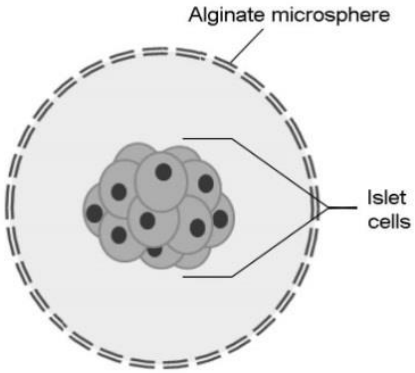


Fig. 3.1

(b) Suggest why Islet cells were encapsulated before they were transplanted into a patient. [1]

- Idea of immune system rejection.

Patients transplanted with human Islet cells obtained from deceased individuals can be made insulin independent for around 5 years using the Islet encapsulation treatment. However, this approach is limited because of the scarcity and quality of donor Islet cells.

(c) Suggest why Islet encapsulation treatment lasts only approximately 5 years. [2]

- The donated islet cells are **specialised** cells that **cannot divide** / **renew themselves**.
- Hence the islets cells would **die** and **stop producing insulin** after 5 years, hence the treatment would stop being effective.

OR

- The alginate microsphere **degrades** after 5 years,
- …the patient's immune system destroys the islet cells, hence no more insulin is produced.

(d) Researchers have also looked into producing human insulin-producing beta cells from stem cells.

A recent study in 2014 used a human embryonic stem cell line (HUES8) and a human induced pluripotent stem cell (hiPSC) line to develop two types of human insulin-producing beta cells called HUES8 SC-β and hiPSC SC-β respectively to overcome the problem of scarcity.

The human induced pluripotent stem cells were derived from fully differentiated adult somatic cells as shown in **Fig. 3.2.**

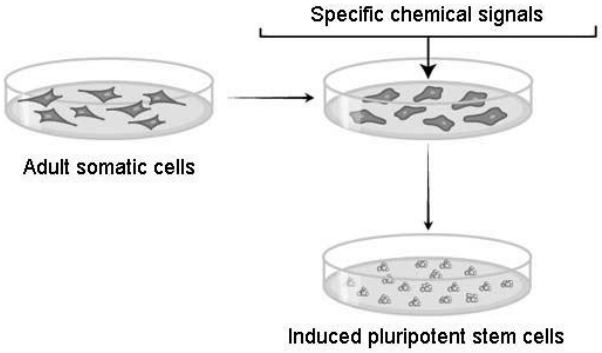


Fig. 3.2

(i) Explain why fully differentiated somatic cells can be induced to become pluripotent. [2]

- Fully differentiated somatic cells contain the **entire genome**
- **Chemical signals** enable the cells to **express genes** important for maintaining **pluripotency /** idea that **genes for pluripotency are turned on**.

(ii) State one ethical issue related to stem cell research and explain how using induced pluripotent stem cells would address this issue. [2]

- Pluripotent cells are usually obtained by **removing the inner cell mass of a blastocyst** and this is problematic as some believe that **life begins at conception** and this is **equivalent to destroying a human life**.
- Using iPSCs does not have as many ethical issues as **no embryos were destroyed in the process**.

(e) Trials have been done by transplanting HUES8 SC-β cells and hiPSC SC-β cells into diabetic mice using alginate microsphere encapsulation. Human insulin produced by the mice was measured following a high carbohydrate meal.

The results of this study were recorded in **Table 3.1**.

Type of beta cell transplanted into diabetic mice	Mean concentration of human insulin secreted ± standard deviation / µg per ml of blood
HUES8 SC-β cells	2.3 ± 0.2
hiPSC SC-β cells	2.2 ± 0.3
Normal human beta cells	2.1 ± 0.9

Table 3.1

(i) Compare the secretion of insulin by these three types of transplanted cells. [3]

Similarity:

- High glucose concentrations resulted in **all three types of cells secreting approximately the same amount of insulin / relatively similar mean amount of insulin**.
- Normal human beta cells, HUES8 SC-β cells and hiPSC SC-β cells secreted 2.1 2.3, 2.2 µg of insulin per ml of blood respectively.

Difference:

- HUES8 SC-β cells and hiPSC SC-β cells showed smaller variation in insulin secretion (with standard deviation of 0.2 µg of insulin per ml of blood and 0.3 µg of insulin per ml of blood respectively) than normal human beta cells (0.9 µg of insulin per ml of blood).

(ii) Explain the purpose of the normal human beta cells. [1]

- As a control / reference to ascertain if HUES8 SC-β cells and hiPSC SC-β cells could produce comparable levels **[key idea]** of insulin in response to high glucose concentrations.

[Total: 14]

QUESTION 4 – Planning question

You are required to plan, but not carry out, an experiment to investigate the effect of temperature on the rate of respiration in mung beans.

Germination of mung beans can be initiated by soaking the seeds overnight. The mung beans can then be placed into a simple respirometer (**Fig. 4.1**) to measure the rate of respiration by measuring oxygen uptake of the seeds. Soda lime pellets absorb any carbon dioxide produced by the germinating seeds. As oxygen is taken up during respiration, the drop of coloured liquid introduced in the capillary tube by capillary action is displaced.

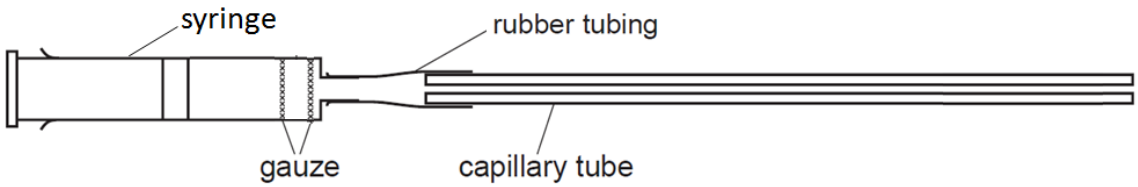


Fig. 4.1: A respirometer

You must use the items from this list:

- 200 mung beans of equal size that have been soaked for 24 hours
- Soda lime pellets 

- Syringes
- Rubber tubing connected to glass capillary tube with 1mm bore diameter
- Beaker of coloured liquid
- Ruler marked in mm
- Paper towels
- Stop watch
- Thermostatically controlled incubator
- Other available laboratory apparatus and equipment

Your plan should have a clear and helpful structure to include:

- a description of the method used including the scientific reasoning behind the method,
- an explanation of the dependent and independent variables involved,
- relevant, clearly labelled diagrams,
- how you will record your results and ensure that they are as accurate and as reliable as possible,
- proposed layout of results tables and graphs with clear headings and labels,
- the correct use of technical and scientific terms,
- relevant risks and precautions taken

[Total: 12]

Suggested answer scheme:

Linking theory to investigation: [1]

- O_2 acts as the **final electron acceptor** in the **electron transport chain** during **oxidative phosphorylation**. The protons and electrons combine with oxygen to form water. The higher the rate of respiration, the higher the rate of O_2 uptake, and the further the displacement of the coloured drop

- As temperature increases, kinetic energy increases, more enzyme-substrate complexes are formed, hence the rate of respiration increases. At optimum temperature, rate of respiration is highest. When temperatures goes beyond the optimum temperature, 3D structure of enzymes involved in respiration disrupted, enzymes are denatured, rate of respiration decreases.

Stating the hypothesis [1]

- As temperature **increases towards the optimum**, rate of **oxygen consumption will increase**, reflecting an **increase in the rate of respiration**.

Independent and dependent variables [1, both variables]

Independent variable: Temperature / °C, with 5 values within a reasonable range (e.g. 15°C, 25°C °C, 35°C, 45°C, 55°C) maintained using an incubator.

Dependent variable: Distance moved by the drop of coloured liquid in 5 min / mm

Variables to be kept constant and scientific reasoning [1, min 1 variable and rationale]

- **Duration** of each experiment should be kept constant to ensure a fair comparison.

- **Number** of **germinating mung beans** used - determines the concentration of enzymes present, and hence affects the rate of respiration. Hence, use the same number of beans (less than or equal to 10 per experiment) for each temperature.

- **Mass of soda lime pellets** (in excess) used should be kept constant as carbon dioxide production will affect the reading of the volume of oxygen absorbed / used up / distance moved by drop of liquid.

- **Volume of air in syringe** used should be kept constant as the volume will affect the amount of oxygen available for respiration.

Methods [2]

- Setting up the respirometer – putting in mung beans, soda lime pellets, coloured liquid
- Describing method to measure dependent variable
- How other variables are kept constant – number of seeds, duration in incubator
- Equilibration of set-up to each temperature / **acclimatisation**

1. Remove the plunger from the syringe and place 2g of soda lime inside the syringe.

2. Weigh 5 g of the germinating mung beans (*Accept 10 or less mung beans*) using a weighing balance and place them in the syringe barrel and replace the plunger by pushing it in until it is about 0.5 cm from the germinating seeds. Connect the glass capillary tube securely to the syringe via the rubber connecting tubing.

3. Dip the end of the glass capillary tube into the coloured liquid so that a drop enters the capillary tube. Remove any excess liquid with paper towels.

4. Set the incubator to 15˚C and place the respirometer horizontally on the incubator shelf.

5. Place a ruler beside the capillary tube and mark the position of the coloured drop.

6. Wait for 3 minutes to ensure equilibration/acclimatization of temperature between the respirometer and the incubator. Also ensure that the drop of coloured liquid is moving smoothly towards the syringe.

7. After 5 minutes, record the distance travelled by the drop of coloured liquid.

Replicates and repeats [1 for 8-9]

8. Repeat steps 1 to 7 to obtain another two readings for this temperature to ensure **accuracy by taking the average reading.**

9. Repeat steps 1 to 8 for the other four temperatures, using fresh germinating seeds.

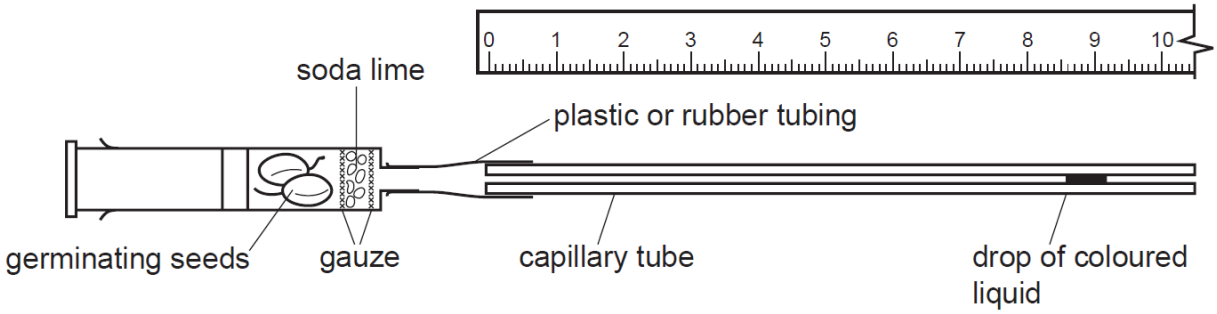
10. Repeat the experiment at **least two more times to ensure reproducibility / reliability** of experimental results.

Controls and justification [1]

- Replace germinating beans with equal mass of **boiled beans** at the optimum temperature.

- Rationale: To show that oxygen uptake is due to the germinating beans undergoing respiration and no other factors

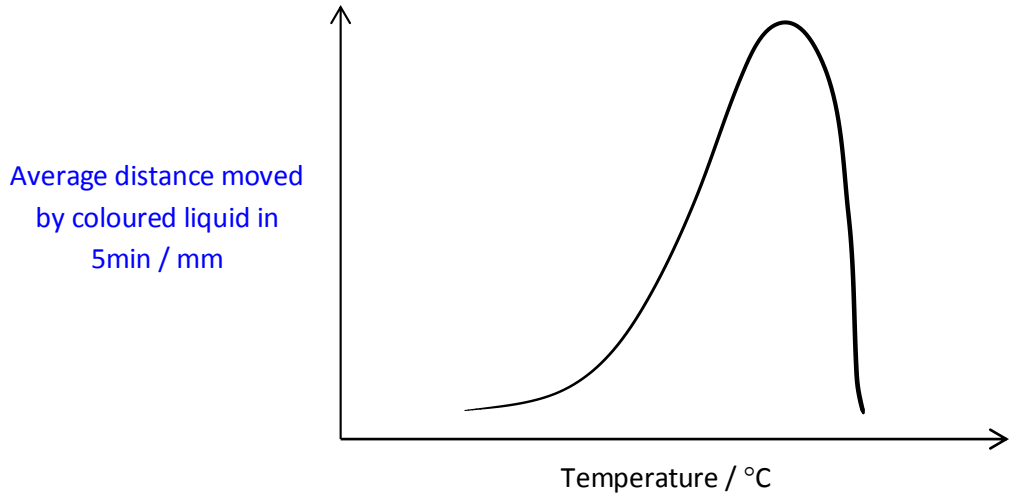
Labelled diagram [1]



Proposed layout of table with appropriate headings (independent & dependent variables consistent with axes of graph) [1]

Temperature / °C	Distance travelled by coloured liquid in 5 minutes / mm			
	Reading 1	Reading 2	Reading 3	Average
15				
25				
35				
45				
55				

Theoretical graph with correct axes and units (optimum temperature included) [1]



Risk assessment and precautions taken [1]

- Soda lime is an irritant/corrosive; handle with gloves and wash affected area immediately if it comes into contact with skin.

QUESTION 5

(a) Discuss the detrimental environmental and economic effects of growing genetically-modified herbicide resistant crops. [6]

Environmental effects:

(1) **Genetically-modified crop plants** may be hardier and become **agricultural weeds** that invade natural habitats
(2) The **introduced transgene(s) to wild species** may result in **more invasive hybrid offspring** when pollen transfer to wild relatives.
(3) **Intensive** use of herbicide selects for **herbicide-resistant weeds**
(4) Intensive use of herbicide **reduces biodiversity**, **upsetting the natural balance of the ecological system**.

Economic effects (4 max):
(5) High cost of GM seeds/plants, farmers cannot afford/ erode farmers' income
(6) Heavy use of herbicide, thus, cost more
(7) contamination of organic farming due to accidental mixing of GM crops with non-GM crops
(8) cleaning pollution associated with heavy use of herbicide
(9) human health problems associated with the use of herbicide

(b) Discuss the ethical and social issues of the Human Genome Project. [6]

Ethical issues arise…

(1) on the **fairness** in the use of genetic information by insurers or other organisations, etc which may create a situation in which less healthy individuals / those with genetic predisposition are marginalised or discriminated.

(2) on the **confidentiality and privacy** of genetic information - the right of ownership of the genetic information has yet to be determined.

(3) on the use of genetic information in controversial decisions in reproduction, such as **modifying genotypes** through gene therapy. Hence resulting in the ethical issue of

a) one generation determining the next generation's genotype before birth without their **consent**.
OR
b) going **against nature** by tampering with the next generation's genetic make-up.

(4) on the use of genetic information in controversial decisions in reproduction, such as **termination of pregnancies**. Issue – selective breeding / abortion based on genetic tests that may not be fully reliable/understood. → increased abortion rate / decline in appreciation of the dignity of life

(5) from clinical issues that the doctors, other health service providers, patients and the public must be educated to make **informed choices**, and be aware of scientific capabilities and limitations.

OR

Unethical for doctors or health care providers to carry out genetic tests
a) and draw conclusions on data that may not be fully reliable, **or**
b) without informing the patient of the limitations and capabilities of genetic technology, **or**
c) leaving patient to interpret complex results without sufficient explanation.

(6) from **commercialization/patenting** of genetic information and their product by companies which may limit their accessibility and development of useful medicinal products.

(7) from the conceptual and philosophical understanding of human responsibility, **free will versus genetic determinism**, and concepts of health and disease. E.g. difficult to determine if a person's behaviour is genetically determined or can be controlled by the individual.

(8) when an individual identified to have life-threatening genetic condition experience **immense psychological ramification**.

Social issue arises

(9) Due to possibility of social and **economic stigmatization/discrimination** as well as **genetic discrimination** that arises due to the knowledge of individual's genetic difference.

(c) Describe how a genetic condition like SCID may be treated with viral gene therapy and discuss the potential limitations of this kind of treatment. [8]

SCID gene therapy: Outline **[Max 6]**

(1) SCID (both types accepted) is a **recessive** condition that may be treated by the introduction of the **dominant normal allele**.

(2) A **retrovirus vector is modified** such that it **does not cause disease.**

(3) **Hematopoietic stem cells or T cells** are harvested from the **SCID patient** and are cultured *ex vivo.*

(4) **RNA** copies of **normal** human **ADA gene** or **ILRG-2 gene** are obtained from **bone marrow** of a donor.

(5) This **ADA RNA** is then used to make a **recombinant RNA** molecule, which is **packaged into the modified retrovirus vector.**

(6) The retrovirus is allowed to **infect** the harvested hematopoietic stem cells / T cells. The recombinant RNA molecules are **injected** into the cells.

(7) **Reverse transcription** catalysed by viral reverse transcriptase occurs and **double-stranded complementary copies of ADA DNA** are produced.

(8) The normal ADA allele **integrates randomly** into the host **genome**. Expression of the ADA allele produces functional ADA enzymes.

(9) The **hematopoietic stem cells / T cells** are **transplanted back** into the body of the patient.

(10) t
These cells **divide** and proliferate to produce **normal** T cells and/or B cells.

Limitations of gene therapy:

(11) If the normal allele is **not** successfully **integrated** into the stem cell **genome**, the treatment is **short term** as the **episomal DNA** may be **hydrolysed** and **gene expression will be lost**. Thus the therapy has to be **repeated**.

(12) If the normal allele is integrated into the host genome at random, **insertional mutagenesis** may occur.

(13) If **viruses** are used to introduce the normal allele, viral **proteins** may trigger an **immune response** in body due to expression of viral genes, and the capsid itself may also trigger immune response.

(14) Virus may regain virulence which cause disease in the patients

[Total: 20]

• END OF PAPER 3 •